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Coalfields & Collieries of Australia

BY

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PREFACE

Coal mining plays so large a part in the mining operations of the Commonwealth, and especially in those of the leading State, that it is matter for surprise that no publication has yet been devoted to its glorification. New South Wales is distinguished among all the Australian States for the varied character and extent of its mineral output; yet, great as is its wealth in gold, silver, copper, lead, zinc, iron, tin, and cement, the value (£3,010,000) of its coal output in 1910 was more than equal to that of its two chief metals, silver (£1,405,000) and zinc (£1,290,000), even though the latter was largely the outcome of the treatment of ore mined years ago. In the value of the State's total mineral output to the end of 1910, coal again takes first place, with a value of more than £62,000,000; gold coming next, with nearly £58,000,000; silver and silver-lead third, with over £52,000,000; and copper fourth, with less than £11,000,000; tin, zinc, shale, iron, lead, noble opal, and cement toiling far behind. The total New South Wales production of coal has amounted to between 160 and 170 million tons, and there can be no doubt of the prominence of this mineral among the factors of the mineral wealth of the State.

Taking the whole of the Commonwealth, we find that coal takes second place, being surpassed only by gold. The total figures for 1910 are not available at time of writing, but those for 1909 showed the value of the gold production to be £12,605,000 to coal's £3,084,000, copper's £2,333,000, silver's £1,500,000 (approximately), and zinc's £1,042,000. In the

total figures also coal comes second, gold easily heading the list with a value of £514,000,000, the value of coal won being £67,000,000, that of copper £54,000,000, that of silver about £45,000,000, that of tin £28,000,000, and that of lead about £16,000,000. Although 89 per cent. of the entire Australian coal output has come from New South Wales, and although in 1909 its percentage of the output was as much as 85, it is yet evident from these figures that coal production plays a most important part in the mining business of the whole of the continent. The subject is, therefore, a big one, and I know no one better fitted to deal with it in the full equipment of a complete knowledge of his subject than the author of this book.

Mr. Frederick Danvers Power, who is a Fellow of the Geological Society, a member of the American Institute of Mining Engineers, of the Institute of Mining and Metallurgy (London), and of the Australasian Institute of Mining Engineers (of which he was President in 1897 and 1904), received his scientific education in Swansea, London, and Clausthal, and has supplemented all he learnt there by much travel in various parts of the world. He came to Australia in 1884, and has since had his residence in this country. For some time he made Melbourne his headquarters, but later he took up his residence in Sydney, where he became Lecturer in Mining at the University—a position which he still holds. He is widely known as the author of a very handy "Pocket-book for Miners and Metallurgists," and of many papers on scientific subjects, a number of which have been printed in the "Australian Mining Standard." He acts as consulting engineer for English mining and exploration companies, and has a wide reputation for sane judgment and for the "conservative" character of the estimates he forms. This work will hardly fail to add to his reputation as a keen judge of mining methods, and a thorough master of his subject.

—Ed. *Aus. Mining Standard.*

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COALFIELDS AND COLLIERIES OF AUSTRALIA

CHAPTER I.

INTRODUCTION.

Coal mining is generally looked upon as distinct to metal mining, for although there may be many features in common, yet they vary greatly in degree, and there are certain points that require special knowledge, which favours treating coal and metal mining as two different classes. Metals mostly occur in deposits that incline to be vertical, while coal has a tendency to be horizontal. Coal is comparatively low in value, while metals are comparatively high, consequently the former must be worked on a large scale, and cheaply. This may cause one to pass by certain narrow seams as unprofitable, and to waste large quantities of coal in thicker seams rather than go to the expense of outside supports. To get away large quantities of material, sufficient transport appliances, both underground and on the surface, must be supplied. Large areas of ground must be secured to make it worth while to go to the expense of an adequate outlay on development and plant. Ventilation demands special consideration, especially in gaseous mines. The coal trade is influenced by a different set of conditions to the metal market, and this has had its effect on customs of coal mining. The coal miner objects to the "dog watch," as he terms the night shift, but the metal miner, though he likes it no better, takes his turn at the night shift as a matter of course. The collier wins his coal at a tonnage rate, while the metal miner, as a rule, works his ore on wages. In many cases, the metal miner has more regular employment than the coal miner, who is often dependent on shipping orders.

Coal is a most important substance in the welfare of a country, as on it depends so many industries; consequently, other things being equal, that country which has the best coal supply has an immense advantage over her neighbours. Even a poor coal is better than none at all, so those countries that

have an inferior supply find it advisable to develop their re sources in case they should be threatened by a coal famine, owing to a shortage or stoppage of supply from elsewhere, due to war, strikes, or other causes, for such an event would paralyse trade, by affecting freights by rail and steamships, besides causing various factories and other industries to close down. An inferior coal may be able to hold its own for certain purposes on the home market, though unsuitable for export, for outside coal is handicapped by freight; the inferior material may also be used for making producer gas, which gives greater efficiency than when employed for steam raising. Without a home supply a country may be affected by events in another place, where it otherwise has neither interest nor influence.

Fig. 1.—Glossopteris browniana.

Fig. 2.—Gangamopteris spathulata.

The coal of New South Wales is a long way ahead of that produced in the other Australian States, both in quantity and quality; in fact, it is the quality that enables it to compete with coal from other States for their home consumption. New South Wales has a further advantage over other parts of Australia, inasmuch as coal is found for a distance of about 200 miles along her seaboard.

An idea of the relative quantities produced in the different Australian States will be obtained by comparing their outputs for 1909:—

	Tons.
New South Wales	7,019,879
Queensland	696,332
Western Australia	214,302
Victoria	128,173
Tasmania	66,162

For convenience of classifying sedimentary rocks, the deposits are arranged in groups or eras; systems or periods; series or epochs; stages or ages, and beds. The second term in each case relates to time. Thus we speak of the Mesozoic group, Triassic system, Hawkesbury series, Narrabeen stage, and Estheria bed.

When one speaks of coal measures it is intended to include not only the coal seams of that series, but also those beds closely related to the seams, which consist chiefly of shales and sandstones of fresh water origin.

The word seam is applied to a bed of coal. It need not necessarily be confined to clean coal, but also includes any

Fig. 3.—Phyllotheca australis.

small bands of stone deposited about the same time, and interbedded in the coal. When two seams occur so close together that they may both be extracted from the same workings, they are known as "twin seams." Coals occur from Palaeozoic to Tertiary times. but certain periods appear to have been more favourable to the formation of coal than others. For instance, in Australia, the Permo-Carboniferous period is that in which our most productive fields of bituminous coal occur, while the brown coal is found in Tertiary strata.

The special conditions that went to form one seam may be expected to recur, though possibly not in the same degree. We rarely find a solitary seam of coal in a series of rocks forming the coal measures, but we often find several seams of various thicknesses and various distances apart.

The following are the commonest typical fossils of Australian coal measures:—Permo-carboniferous.—Plants. *Glos-*

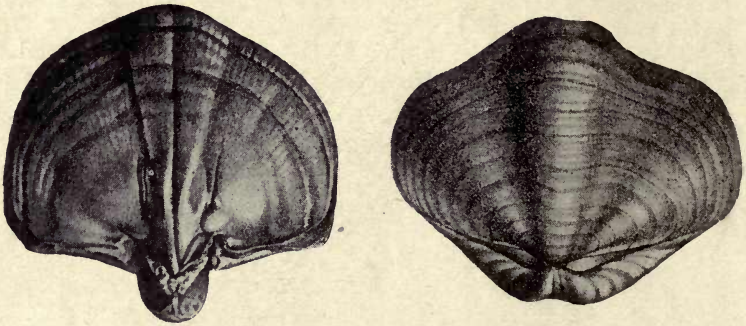

Fig. 4.—Martiniopsis subradiata.

sopteris browniana (Fig. 1). Vertebraria. *Gangamopteris, spathulata* (Fig. 2), *Noeggerathiopsis hislopi, Sphenopteris lobifolia, Phyllotheca australis* (Fig. 3), Inverterbrates. *Martiniopsis subradiata* (Fig. 4), *Spirifera tasmaniensis, Spirifera vespertilio* (Fig. 5) *Productus brachythaerus* (Fig. 6), *Dielasma hastata, Eurydesma cordata* (Fig. 7). *Chaenomya ethe-*

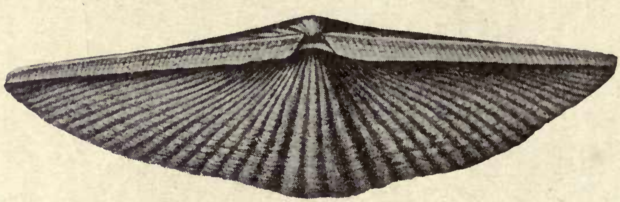

Fig. 5.—Spirifera vespertilio.

ridgei (Fig. 8), *Deltopecten illawarrensis, Pleurophorus gregarius, Platyschisma oculum* (Fig. 9), *Conularia inornata, Goniatites micromphalus, Stenopora crinita. Zaphrentis cainodon, Triprachiocrinus.*

Lower Mesozoic.—Plants.—*Taeniopteris daintreei* (Fig. *Thinnfeldia odontopteroides* (Fig. 10), *Sphenopteris australis* (Fig. 12), *Podozamites lanceolatus* (Fig. 11).

(Figure 11 is after the classification of Seward, Figs. 7 and 9 after Mitchell, the plants after Feistmantel, and the rest after De Koninck).

The two chief theories as to the formation of coal are:—(1) That the vegetable matter which went to form the coal grew where it is now found. (2) That the vegetable matter drifted to its present position. We must remember two important points when considering the formation of earlier coal seams:—(1) That the climatic conditions and configuration of the earth's surface were different then to what they are now; and (2) that vegetation had not reached the same high state of organism that we have now-a-days. It is admitted that in some cases coal has been formed by drift material, such as might be floated down some gigantic river, but drift packs are of comparatively rare occurrence, and coal formed by them would break up more readily than when compacted in situ.

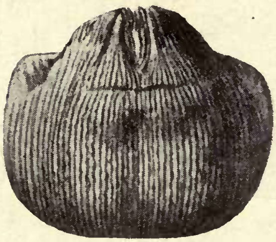

Fig. 6.—Productus brachythærus.

Fig. 8.—Chænomya etheridgei.

Observed facts fit in better with the idea that coal was formed where the vegetation grew. We find roots of trees firmly embedded in the under-clays of coal seams, and it is easier to understand how thick seams were added to by growth, rather than by accumulations of shifting rivers. Near Catherine Hill Bay jetty, the forms of stumps of large trees are to be seen in situ on the top of the 14ft. seam, the stems of which pass a few inches into the conglomerate roof. Similar growths are to be seen in other places where that portion found in the seam has been absorbed into the coal, while that in the roof has been partly converted into chalcodony. The various layers of coal and rock show that the coal basins became submerged at intervals. We would expect to find coal due to driftwood more impure with sand and mud, than if it were formed in situ, and the dimensions of the seams to be more irregular. The margins of forest-covered swamps in the valley and

delta of the Mississippi are surrounded by dense growths of reeds, which filter the water from all sand and mud. The strata associated with coal consist chiefly of sandstones and shales. The sandstones frequently show ripple marks, and current bedding; the shales are generally laminated, indicating a slow and tranquil deposition. Investigation strengthens the probability that coal was generally deposited in fresh, and sometimes estuarine waters. There are three successive phases that may be distinguished in the formation of coal—first, the accumulation of vegetable matter; second, the work done by chemical action under water, including dehydration and deoxidation of the cellulose, during which the mass shrinks from 10 to 30 per cent. of the original volume of accumulated matter; and, third, subsequent reactions underground. The following table gives

Fig. 7.—Eurydesma cordata.

Fig. 9.—Platyschisma oculum.

a fair idea of the relative proportions of carbon, hydrogen, and oxygen in certain fuels:—

Fuel.	Carbon.	Hydrogen.	Oxygen.
Wood fibre (cellulose) ..	52.65	5.25	42.10
Peat	60.44	5.96	33.60
Lignite	66.96	5.27	27.77
Brown coal..	74.20	5.89	19.91
Bituminous coal	76.18	5.64	18.08
Semi-anthracite	90.50	5.05	4.40
Anthracite..	92.85	3.96	3.19

The steady increase in the amount of residual carbon, and the decrease in the amount of oxygen is plainly seen. Neither vegetable matter at the one end nor anthracite at the other end of the changes cake; while of bituminous coals, having a similar ultimate composition, one may cake and the other not.

Vegetable matter is capable of decomposing in five different ways, depending chiefly on the absence or presence of air and water:—(1) Destructive distillation. Heat in the presence

of air converts organic matter into gaseous products. Heat, in the absence of air, will drive off volatile hydrocarbons, and leave fixed carbon behind; but this is not coal. (2) Mouldering. When decomposition takes place with an insufficient supply of oxygen to completely oxidize the organic matter, a residue, rich in carbon, is left, such as vegetable mould. (3) Peatification. This is carried on under water. At first, the process

Fig. 10.—Thinnfeldia odontopteroides.

Fig. 11.—Podozamites lanceolatus.

is similar to mouldering, only with less air available. In the second stage the oxygen is completely cut off. (4). Putrefaction. This is decomposition under conditions of material temperature when air is absent. (5). Dry rot.

Coal is undoubtedly due to a series of transformations of vegetable matter. In some cases, its structure can be seen under the microscope, or even with the naked eye, and the transformation, commencing with peat, can be followed in its various

stages, though we may not be able to see the change actually taking place. To borrow an illustration from the late Charles Kingsley—bread does not look like wheat, yet it is chiefly formed from it.

There are three ways by which we may ascertain how certain changes came about—by observation, by experiment, by

Fig. 12.—Sphenopteris australis.

deduction. When possible, all three methods are employed in the search after truth, so that one can check the other. It is, of course, impossible for us to see coal made from vegetation

that grew millions of years ago, but we can observe certain changes taking place in our peat swamps. We may learn much from experiment, although we cannot follow nature closely, so far as the time element is concerned, and we have to assume, to a certain extent, the conditions that then prevailed. Deductive reasoning, after all, throws most light on the subject, but we must be careful not to confound facts with fancies.

So far as can be ascertained, the plants that went to form our coal seams required damp places, such as reeds, mosses, and ferns. Swampy plants spread out laterally in search of water rather than vertically, for even a small thickness of peat renders respiration for plant life impossible.

With compression, and the elimination of some of the oxygen and hydrogen, as carbon dioxide and carburetted hydrogen, peat may completely change its nature. In peat bogs, we may see the moss growing at the surface, while at the bottom it is so altered that it is difficult to distinguish the vegetable matter. Under a pressure of 6000 atmospheres, peat is converted into a hard, black, brilliant substance, having the physical aspect of coal, and showing no trace of organic structure. Apparently pressure and increased terrestrial movements cause carbon dioxide and carburetted hydrogen to be given off, and as these gases escape, the percentage of carbon increases. In Pennsylvania, U.S.A., the coal becomes more anthracitic as it passes into regions that have undergone great plications. At Mons, France, the same seam that yielded bituminous coal at the surface gradually passed downwards into anthracite. The deepest collieries in New South Wales are known to be the most fiery. A seam may be of one kind of coal on one side of a parting, and another kind on the other side.

Fig. 13.—Tæniopteris daintreei.

Ordinary bituminous coal is generally made up of layers of bright and dull coal. The bright coal is supposed to be made up of peaty material, while the dull is composed of sapropels, which is a mud formed by the decay of vegetable matter, and its presence indicates submergences due to floods. Bands of slate of varying thicknesses may also occur in coal seams, but a seam must not be condemned on account of it partings, provided they can be easily separated from the productive part of the seam. Sometimes when the coal is green, i.e., freshly mined, these bands

are not readily separated, but, say, an inch of coal clings to each side of them. After exposure to the weather, however, the parting may come clean away. Thin bands are not easily separated, so go to increase the ash of coal. The fireclays frequently found below coal seams are believed to be the old soils on which the vegetation grew that is now preserved as coal. The original soil has been deprived of its soda, potash, lime, magnesia, and iron, by leaching, and as these constitute the fluxes, the residue forms a fireclay.

Coal may vary considerably in its nature and value, according to its position, as pressure has a great influence upon it. With regard to outcrops, if the surface is badly cut up into deep gullies, the more dirty coal is likely to be found under the long and narrow points, since it withstands disintegration better than good coal, which is more likely to be found in the compact ground. The pressure of superincumbent strata is likely to thicken a plastic bed at its outcrop, as there is little resistance to balance it. This increase of thickness along a line of outcrop in a gully tends to give the strata a local upward tendency. Should the roof of the coal be sandstone, while underfoot there is a considerable thickness of slate and clay, then, as the latter are more plastic, and are swelled by the action of the atmosphere, causing great pressure from below, the coal is likely to be thinner at the outcrop than further in. If slate forms both the roof and floor, the coal is not likely to be thus affected. A soft, sooty material at the surface may pass into a coherent, friable and pure material. Hard streaks in coal are more pronounced at the surface, and may give it a dry, dead appearance. Further under cover, such a coal may become of fair quality, owing to the increase of volatile and oily substances, and a proportional decrease in ash. A black, friable, slaty material usually passes into an inferior coal. As a general rule, individual coal seams become more tender as depth is attained, and deep lying seams of bituminous coal are more likely to be gassy than near the surface.

A peculiar spheroidal form of coal known as "coal apple" is of frequent occurrence in the Borehole seam, especially in the Bullock Island, Stockton, and Australian Agricultural Company's collieries, at Newcastle, New South Wales. Such forms have been noted in other parts of the world, and described*, but so far their origin appears to be a mystery. These coal apples occur both in anthracite and bituminous coal seams. The size and shape of the apples vary; the former depending, to a great extent, on how the specimen has been trimmed down, the stucture becoming more perfect towards

*W. S. Gresley, "Note on Anthracite 'Coal Apples' from Pennsylvania" Trans. Am. Inst. Min. Eng., XXI., 824.

the centre of a block of coal. These spheroidal bodies are not nodules in the strict sense of the word, but are forms caused by a system of jointing, producing overlapped joints after the coal has acquired its ordinary jointing, for some apples show a concentric structure through which the ordinary cleavage of the coal passes. The more brittle the specimen, the more indistinct the grain. Sometimes composite apples occur in which a smaller apple becomes enveloped by a larger one. Professor Liversidge, of the University of Sydney, gives the following analyses of a nodule, and a sample of the seam enclosing it:—

	Coal apple.	Seam.
Carbon	83.828	81.06
Hydrogen	5.437	5.81
Oxygen	8.236	6.52
Sulphur	.190	1.14
Nitrogen	.530	1.23
Ash	1.779	4.24
	100.000	100.00
Sp. Grv.	1.294	1.24

The proximate analysis gave:—

	Coal apple.	Seam.
Moisture	3.32	2.21
Volatile Hydrocarbon	32.41	36.70
Fixed Carbon	62.35	55.82
Ash	1.72	4.15
Sulphur	0.19	1.12

The sample of the seam was that of the whole seam, and as the composition of the several beds comprising it varied, this may, to some extent, account for the difference in the analysis. Anyhow, one cannot expect to draw fair conclusions from one set of results. In other countries, the analysis of a coal apple and the seam in which it was found appear to be much the same; sometimes one being a little higher in carbon, and sometimes the other. This looks as if the change was purely physical, not chemical.

Most coals contain gases occluded in them, which are given off on exposure to the atmosphere, sometimes with considerable force, when they are known as "blowers." In some mines, one can hear the gases continuously fizzing out of the face. The gases held by coal are methane, carbonic dioxide, nitrogen, and oxygen. They are present in various quantities and proportions. The quantity of occluded gases in coal does not appear to influence its liability to explosions. A dense coal may occlude more gas than a softer coal, but the latter, on account of its more porous nature, may readily yield up the gases contained in it. Sometimes the gases are

tapped from the seam beforehand, by means of bore-holes, and may be conducted along pipes to the surface.

Pyrites, known as "brasses," is of common occurrence in coal seams. There are two forms of pyrites, having the same formula, viz., iron pyrites, and marcasite, composed of two parts of sulphur to one of iron; yet these two minerals vary in other respects, both physically and chemically. Marcasite is more readily decomposed, and in doing so generates considerable heat within a shorter period than iron pyrites. As the "brasses" of coal miners is often marcasite, it is highly probable that the oxidation of this mineral may be an important factor in some cases of spontaneous combustion.

A. P Brown† makes some interesting suggestions to account for the difference between pyrite and marcasite. He writes:—"In nature, it would seem that in most cases the sulphide of iron first formed is Fe S (ferrous), but probably by action of a ferric salt or carbonic acid (H_2CO_3) causing a loss in iron, FeS_2 results, and this is almost always pyrite. On the other hand, where ferrous sulphate has been reduced by the slow action of decomposing organic matter, the resulting sulphide seems to be generally marcasite, which, if not in crystals, may be recognised by its ready weathering to ferrous sulphate ($FeSO_4$). This compound may, however, in many cases, be a mixture of pyrite and marcasite, as much pyrite seems to be."

Pyrites contains a large amount of ferric iron, while in marcasite the iron apparently exists in the ferrous condition. Mr. Brown then goes on to explain that if we look upon the iron in marcasite as a dyad ($Fe^{ii}S_2$), the bonds of the sulphur atoms are not all saturated with iron, so that a bond of each has to combine with sulphur. Such combinations are weak, and liable to oxidation more readily than when sulphur and iron bonds are connected. He expresses the probable structural form of marcasite by the following graphic formula:—

Iron pyrites ($Fe\ S_2$), he looks upon as having a constitutional formula ($4\ Fe^{iv}S_2$, $Fe^{ii}S_3$).

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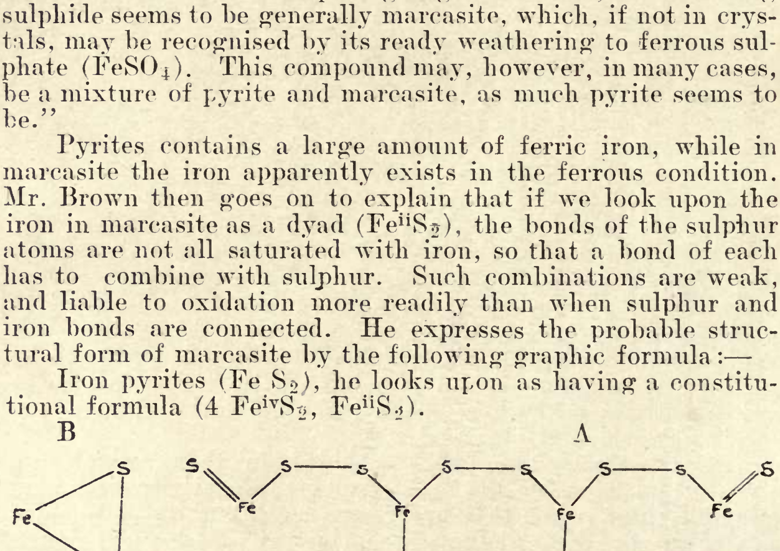

†A. P. Brown, "A Comparative Study of the Chemical Behavior of Pyrite and Marcasite." Proc. Am. Phil. Soc. XXXIII. 226.

He proposes the above structural formula, not as expressing the exact constitution of the compound, but as an expression of the iron in the molecule, and as embodying in a quantitative way the results of his investigation into its constitution. It will be noticed that the sulphur of the Fe^{ii} S_2 is made to link entirely with iron. He considers the ferric iron is most likely Fe^{iii}; anyhow, he thinks that the simplest way to regard it.

Fires may occur in coal seams from natural causes, even in cases where the seam has never been worked. In 1838, Surveyor-General Mitchell, referring to the so-called burning mountain, Mount Wingen‡, stated that there was evidence of the fire having existed for a considerable time previous to his visit. This fire is still burning, its progress being indicated by cracks taking place in the overburden on ahead, and a subsidence of the ground behind the fire. This coal seam belongs to the Greta series of the Lower Coal Measures, and from the fused condition of the rocks about it at Cessnock, it has evidently been alight there also. This seam appears to be very liable to spontaneous combustion, for the Homeville Colliery, in the Maitland District, was sealed down for fourteen years on account of a fire, and when re-opened, it fired again. The Greta and East Greta Collieries have also had cases of fire. J. E. Carne|| writes:—"On the edge of the Coal Measures, south-east of portion thirty-eight, Parish Coco, County Roxburgh, the second lowest coal-seam—about one hundred and ten feet above the base of the Marangaroo Conglomerate—is on fire over a small area, probably having been ignited by a burning root during a bush fire, or, possibly, by decomposition of secondary pyrites by infiltration of water."

Coal, strictly speaking, is not a mineral, for the definition of a mineral is a "natural homogeneous, inorganic substance," and coal is of organic origin. Nevertheless, as it occurs in nature like a mineral, it is convenient to look upon it as such. A satisfactory definition of coal has not yet been made, for coal is not uniform in composition, or physical features, and there is no sharp line between the different types of coals, which run one into the other. For the sake of convenience, we may look upon coal as being a solid fuel, which occurs in seams, formed by the fossilised remains of organic matter. This would exclude oil and natural gas, since these

‡"Three Expeditions into the Interior of Australia. I.p. 23 (London, 1838).

||"The Kerosene Shale Deposits of New South Wales," p. 136 Sydney (1903).

are not solid. It would not include kerosene shale, as this is not employed as a fuel per se, but as a producer of oil or gas, neither would it include asphalt, ozocerite, and such like substances, which cannot be looked upon as fuels. Coal, in a mineralogical sense, must not be confused with coal in a commercial sense, any more than "ore" in a mineralogical sense, which means any metallic mineral, should be confused with "ore" used in the technological sense, which means any mineral or mineral compound from which metals or metallic combinations can be obtained in an economic manner; thus including the gauge, or matrix, as well as the ore proper. A coal seam may be so impure that certain portions of it may not be worth working, in which case only the commercial coal is extracted; unless it is necessary to break down the inferior coal for head room, when, being broken, the lesser price it realises may go towards covering the expense of raising and marketing it. Since coal mining is prosecuted with the object of making money, it must be obvious that when a lessee agrees to extract all the coal, it is understood to mean that quality of coal on which a profit can be made, for it is not a custom of the trade to mine, and place on the market a product for which there is no sale. To force a lessee to mine, and pay a royalty on worthless material, or that which would cost more than the product was worth to clean it, would be shortsighed policy, though it has been tried, for either the lessee would be ruined in time, or else his coal would get such a bad name that his output would be diminished, and, in consequence, the amount of royalty paid per annum. It is neither fair nor equitable to force a lessee to work an unpayable portion of a seam at the expense of the good coal.

Coals being variable mixtures, do not lend themselves to a strictly scientific classification. What consumers require is some simple method of distinguishing different varieties, typical examples of which are readily recognised, more especially those whose qualities render them valuable for certain purposes, such as gas-making, steaming or coking. So far, there has not been any special attempt to classify Australian coals. Turning to the work done in other countries, classification, whether based on physical characteristics or chemical composition, have neither of them proved satisfactory. The term bituminous includes a great variety of coals that require subdividing. If we take the results of proximate analysis, these include impurities which are largely a matter of accident during the formation of the coal. If we take the physical properties of coals, these give no adequate idea of their composition. The classification adopted by the Pennsylvanian Geological Survey was based on the fuel ratio, i.e.,

fixed carbon to volatile hydrocarbons, and from this they adopted the following ratios:—

Anthracite..	fuel ratio from	100 to 12
Semi-anthracite	fuel ratio from	12 to 8
Semi-bituminous	fuel ratio from	8 to 5
Bituminous..	fuel ratio from	5 to 0

This scheme classified all the bituminous coals together, good and bad, but made no provision for lignites. Carbon is the prominent element in coals, but its value depends on whether it occurs as fixed or volatile hydrocarbon. A classification according to fixed carbon is fairly satisfactory when the amount of hydrocarbon is small, but lignites and low grade bituminous coals are apt to become confused lower down the scale.

A classification according to the calorific value is fairly satisfactory so far as the lower part of the scale is concerned, but there is still some uncertainty about the division between lignites and bituminous coals. Lignites are noted for their large percentage of moisture, so Collin proposed (Bulletin No. 218. U.S.A. Govt. Surv. 1903) a moisture content of 10 per cent. as a basis of separation between lignite and bituminous coals; but it was found that certain bituminous coals contain more than 10 per cent., while some lignite contained less. If we turn to ultimate analysis and recalculate, excluding ash and sulphur, there are hydrogen and carbon to consider. If hydrogen is taken as a basis there is still a difficulty in distinguishing between coal and lignites. If carbon is taken, the classification is satisfactory generally, but not in certain details where some coals appear to be misplaced. As neither of these fuel elements alone appear to fit all cases, a classification has been provisionally proposed by Mr. R. Campbell, based on the carbon-hydrogen ratio. When taking these into consideration they should not be added or multiplied, as these processes would tend to equalise the results, but they should be subtracted or divided, preferably the latter. Mr. Campbell writes* "So far as I am acquainted with the character and fuel value of the coals tested, the classification of coal according to carbon-hydrogen ratio seems to be almost ideal. It is not only correct in a general way, but in detail it seems to fit almost every case. True, the separation between bituminous coal and lignite is not sharp and distinct, but it is highly probable that there is no sharp distinction between these two classes, and that the facts are best represented by a merging of

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*"The Classification of Coals." Trans. Am. Inst. Min. Eng., XXXVI., 338 (New York, 1906).

values." He then draws up the following table of proposed groups of coal:—

		Carbon-hydrogen ratio.
Group A,	(graphite)	infinity to (?)
Group B,	(anthracite)	(?) to 30 (?)
Group C,		30 (?) to 26 (?)
Group D,	(semi-anthracite)	26 (?) to 23 (?)
Group E,	(semi-bituminous)	23 (?) to 20
Group F,		20 to 17
Group G,		17 to 14.4
Group H,	(bituminous)	14.4 to 12.5
Group I,		12.5 to 11.2
Group J,	(lignite)	11.2 to 9.3
Group K,	(peat)	9.3 to (?)
Group L,	(wood cellulose)	7.2

Professor H. D. Rogers proposes the following as a commercial clasification of coals:—

	Volatile Matter Per Cent.	Fixed Carbon Per Cent.
Anthracite	below 6	90-94
Semi-anthracite	below 10	84-90
Semi-bituminous	between 12 and 18	52-84
Bituminous	above 18	75-80
Hydrogenous or gas coal, cannel, torbanite.		

This classification, however, does not fit all cases; there is no rigid division and some overlap.

Varieties of Coal.

Anthracite, hard or stone coal, is the hardest and most lustrous of all coals. It gives great heat, burns with little flame and no smoke. It is valued by man-of-war ships. Its specific gravity varies between 1.3 and 1.7; it does not soil the fingers, has a deep black color, but is sometimes iridescent, when it is known as "peacock coal." The fracture is conchoidal, lustre brilliant, and sub-metallic, or resinous to dull "Dry coals" are those wanting in oily constituents, in contra-distinction to "fat" or gas coals.

Semi-anthracite.—This is neither so dense nor so hard as true anthracite. Its contents of volatile hydrocarbon is greater and it ignites more readily.

Semi-bituminous coal is generally not so hard as bituminous coal, and its fracture is more cuboidal. The percentage of volatile matter is less. It kindles readily, burns with a steady flame, and makes a good steam coal.

Bituminous, or soft coals may be further subdivided into coking or caking and free burning coals. The term "bituminous" does not mean that these coals contain bitumen, which as a rule they do not. Bituminous coal has a specific gravity of 1.25 to 1.40, it is generally brittle, has a bright

pitchy or greasy lustre, and burns with a more or less smoky flame; on distillation it gives off gas. Some coals of similar chemical composition may coke, while others will not. The reason for this is not properly understood; even a coking coal often loses that property on being weathered for a short time, although its composition is apparently the same according to analysis. This is probably due to the breaking down of certain hydrocarbons and a recombination of the elements.

Free-burning or cherry coals burn freely without softening or fusing together.

Splint, or splent, coal is a Scottish name, given to this variety on account of its splitting or splenting up like slate, but it breaks with difficulty on the cross fracture. It is a hard laminated variety of bituminous coal and has a dull black color. Being hard it carries well. It makes a hot fire and burns well in an open grate. The so-called "splint" coal associated with New South Wales kerosene shale is more correctly a "cannel." Some people are under the impression that the distinguishing feature of splint coal is due to stony matter in it, but this is not always the case, as proved by analysis.

Cannel Coal, kerosene shale and oil shale are closely allied and frequently confounded. They are characterised by their high ratio of volatile to fixed carbon. Cannel coal derives its name from the fact that it burns with a bright flame like a candle. It is also known in Scotland as "parrot coal," because it makes a chattering or crackling noise when burnt. It is compact, with little or no lustre; breaks with a conchoidal fracture; kindles readily, and burns with a dense smoky flame. It is rich in disposable hydrogen, and is mainly used in the manufacture of gas. It consists of a preponderance of ordinary carbonaceous and thoroughly macerated vegetable matter.

Kerosene shale, or torbanite, is brownish-black to greenish-black in color; streak, yellowish to brown; lustre, dull to satiny; texture, very fine; fracture, conchoidal, more especially across its plane of bedding; it is easily split. It consists of a preponderance of spores, and thalli of algae. The New South Wales kerosene shale excels that of all other countries both in the number and extent of its deposits. The first-class quality, yielding over 65-70 per cent. volatile hydrocarbon, will stand the expense of export, while the seconds and dressings are used locally. The Joadja shale yields 89.5 per cent. volatile hydrocarbons, against 71.17 per cent., the highest analysis shown from Torbane in Scotland. The lighter the shale the better the quality. When distilled, the New South Wales shale yields from 50 to 150 gallons of crude oil per ton, containing over 60 per cent. refined kerosene, the remaining products being gasolene, naphtha, paraffin, lubricating oil,

ammonia and pitch. The gas producing capabilities of the mineral are stated to have amounted to 18,000 cubic feet per ton, with an illuminating power of 38 to 40 candles, each burning 120 grains of sperm per hour.

Oil shales contain a preponderance of mineral matter.

Lignite strictly speaking should show a woody structure. Brown coal is a name given to a structureless variety which generally contains a larger proportion of carbon and less oxygen than true lignite. The color is generally brown or a brownish-black, but is sometimes pitch-black. It kindles readily and burns rather freely with a yellow flame and comparatively little smoke, but gives only a moderate heat. The ash is often very light, so is readily blown about. It is always high in moisture, which ranges between 10 and 20 per cent.

Uses of Coal.

Good gas coal should have a low percentage of ash, say 5 per cent.; the sulphur should not be more than about 0.5 per cent., while the volatile matter, which should be charged with rich illuminating hydrocarbons, ought to be in the neighborhood of 37 or 40 per cent. The coal should coke well, and produce about 60 per cent. clean, strong, bright coke, after carbonisation, which becomes a valuable product.

For household purposes a coal should maintain a mild, steady combustion, and remain ignited at a low temperature with a comparatively feeble draught. A smoky flame is objectionable as producing soot. A very free or fiercely-burning coal is not desirable, as the temperature cannot be regulated. If the coal contains pieces of slate they are apt to fly out into the room. The ash must not be so stony that it cannot pass through the bars of the grate, nor so light that it blows about the room. Sulphur is objectionable; it not only produces stifling gases when the draught is bad, but it corrodes the grate and tarnishes silver.

Coal for use in a blacksmith's forge should possess a high heating power. The amount of sulphur present should be small, if any; the coal should also be low in ash, and it should coke sufficiently to form an arch.

Coal may be looked upon as consisting of gas, fixed carbon and impurities—water, sulphur and phosphorous. Coal, even in the same seam, may vary considerably, as shown by analysis, which have to be made occasionally, either for the information of the manager, or for selling contracts. The nature of coal may be influenced by the kind of plants that went to form it, also by the pressure to which it has been subjected. Besides the ordinary proximate and ultimate analysis of a coal, one should note other characteristics, such as if it is tender and breaks up too readily, whether it is liable to spontaneous combustion, etc.

CHAPTER II.

Sampling.

Mr. R. Campbell, who was one of the committee engaged on the coal testing plant of the United States Geological Survey, at the Louisiana Purchase Exposition, St. Louis, Mo., in a paper read before the American Institute of Mining Engineers in May, 1905, entitled "The Commercial Value of Coal Mine Sampling," proposes that when sampling a colliery, a fresh face of coal should be selected, free from all powder stains and other impurities. A channel should then be cut across the face of the coal from roof to floor of such size as to yield at least five pounds' weight of coal for each foot of thickness of the coal seam. All material encountered in such a cut should be included in the sample, except partings over quarter of an inch in thickness, and all concretions of pyrites, or other impurities, greater than two inches in maximum diameter, and half an inch in thickness. The sample should be broken down on a cloth protected by boards, so that it shall not become mixed with any dirt on the floor. The sample may be sent to the laboratory as cut, or it may be quartered down to a convenient bulk at the face: in the latter case it is first reduced in size to about three-quarters of an inch. The operation of pulverising and quartering should be done as rapidly as possible, to prevent loss of moisture content, and the sample should be at once sealed in a glass jar or tin. An analysis of such a sample will show the grade of coal that may be obtained by careful mining and picking, but in the majority of cases the commercial output of the mine will contain more sulphur and ash than shown by such an analysis, because the sampling is done more carefully than the mining on a larger scale, but the value of the latter may be approximated by multiplying the analysis by certain coefficients. The coefficients are obtained by adding together the percentage of ash or sulphur, as the case may be, of a given number of samples taken from the strips as ordinarily mined, and dividing this by the total ash or sulphur found in the same number of specially taken mine samples. Since a sample is supposed to represent what it is taken from in everything except bulk,

should a sample be incorrect it is misleading and valueless. All coal seams are not equally good, even parts of the same seam may vary in value, so it is quite possible to pick a sample that will be much superior to what is mined on a large scale. Analysis of samples taken years ago may not be representative of what is mined at the present day. The owners of a mine that produces an inferor coal are not anxious to publish the fact, though it soon becomes known in the trade; even those who produce the better class of coal naturally prefer to give prominence to their best results. Many published comparisons of coals from different places are worthless, since the samples were not taken under similar conditions. The analysis of lump coal is nearly always better than the run-of-mine from the same seam.

Ultimate Analysis.*

To determine the carbon and hydrogen, an Erlenmeyer's combustion furnace is used, with 25 Bunsen burners. The combustion takes place in a piece of combustion tubing, about 1m. long and 18mm. internal diameter: this allows the tube to project about 10 c.m. at each end of the furnace, which projecting portions are protected from the heat by a closely fitting circular shield of asbestos. Air and oxygen are passed through the tube over the sample, but so as to eliminate any carbon dioxide or moisture it may contain, it first has to pass through a purifying train. The purifying reagents are arranged in the following order: sulphuric acid, potassium hydroxide, soda-lime, and granular calcium chloride. The end of the tube near where air and oxygen enter can be closed by a rubber stopper, as there is no fear of volatile matter being given off, since cool air passes through, but the other end is closed with a closely-fitting, well-rolled cork. The rear, or cool end of the tube, is empty for 25 c.m. inside the furnace, the next 25 c.m. is filled with a loose layer of cupric oxide, with a plug of acid-washed and ignited asbestos at either end, to keep the wire-copper-oxide in place. After the copper oxide comes 10 c.m. of coarse fused lead chromate, to retain any sulphur products, this also being held in place by a plug of asbestos. The absorption train consists of a six-inch Marchand U tube, filled with granular calcium chloride, to absorb water formed by the oxidation of the hydrogen; this is followed by ordinary Liebig's bulbs, containing potassium hydroxide, to which is attached a three-inch U tube, containing soda lime

*E. W. Parker, J. A. Holmes, and M. R. Campbell. Report on the operation of the Coal Testing Plant of the United States Geological Survey (Washington, 1906, published by authority).

and calcium chloride, to absorb the carbon dioxide formed by the oxidation of the carbon: the bulbs and U tube are weighed together. A final guard tube, filled with calcium chloride and soda lime, is fixed on to the end. The gases formed during combustion are drawn through the train by suction, a Marriott bottle being used to secure a constant suction head. The oxygen is supplied under a slightly greater pressure than the aspirator, so that there shall be no fear of leakage of the combustion gases into the gasometer.

The sample of coal is well mixed and ground: 2-10ths of a gram are weighed out into a platinum boat, about 70 mm. long and 8 mm. deep, which is pushed into the rear of the combustion tube up to the asbestos plug, which holds the copper oxide in place. That part of the tube holding the boat is kept cool till from 20 to 25 c.m. of the copper oxide is at a bright red heat, and the lead chromate heated to a barely visible red. The burners at the back of and under the boat are then turned on very gradually, and the volatile products slowly driven off; a slow rate of aspiration, one or two bubbles a second, being kept up; care must be taken not to drive them off so rapidly as to cause back pressure. If the combustion is too rapid, the ash may fuse and retain unburnt coal. The ash must be examined for unburnt carbon. The ignition is characterised by considerable glowing. Oxygen is passed through the train for several minutes after the last evidence of combustion has disappeared, or till it begins to bubble freely through the potash bulbs. About 1200 c.c. air are then aspirated through the train before weighing up. The absorption train is carefully weighed, both before and after the combustion: 100 parts of CO_2 represents 27.27 parts of carbon: 100 parts of water represents 11.11 parts of hydrogen.

Sulphur.—The total sulphur may be determined by Eschka's method. One gram of the finely powdered coal is mixed by means of a glass rod in a 30 c.c. platinum crucible, with half a gram of the Eschka mixture which consists of 1 pt. dry sodium carbonate and two parts of the light porous variety of magnesium oxide: this is afterwards covered with about half a gram of the Eschka mixture. The crucible is then heated over an alcohol lamp, which is moved about by hand: gas must not be used on account of the sulphur it contains. At first the flame is kept low, and is scarcely allowed to touch the bottom of the crucible until the volatile matter has been burnt out, which takes from 15 to 30 minutes: the heat is then increased, and the contents of the crucible stirred with a platinum wire till all trace of unburnt carbon has disappeared. As the complete burning of coke over an alcohol lamp is very difficult, the final burning may be done in a gasoline muffle furnace. The mixture is transferred from the crucible to a

beaker, where it is digested with 50 to 75 c.c. of water for 30 minutes; filter, wash the residue twice with hot water by decantation, then wash on the filter, small portions of water being used for each washing, till the filtrate amounts to 200 c.c. Bromine water is then added, the solution being made slightly acid with hydrochloric acid. The amounts generally used are 4 c.c. of water saturated with bromine, and 3 c.c. of concentrated hydrochloric acid. Heat the solution to boiling till the bromine is expelled, then precipitate the sulphur with 22 c.c. of a hot 5 per cent. solution of barium chloride, which is slowly added from a pipette during constant stirring. The precipitate is allowed to stand at a temperature a little below boiling for two hours, or longer, before filtering. Test the filtrate for acidity with litmus paper, and for excess of barium chloride with a drop or two of sulphuric acid added to a little in a test tube. The preliminary washing of the precipitate is done with hot water containing 1 c.c. hydrochloric acid per litre, the final washing being made with hot water alone, and the washing continued till it no longer reacts for chlorine when tested with nitrate of silver. Ignite the filter paper and precipitate in a porcelain crucible, using a low heat till the paper is burnt off; then raise the heat sufficiently to bring the precipitate to a dull redness, and continue heating for a few moments, cool and weigh as barium sulphate.

			Per cent.
Ba	137	=	58.8
S	32	=	13.7
O_4	64	=	27.5
	233		100.0

If one gram of coal was taken, then

$$S \text{ per cent.} = \frac{\text{Weight of } BaSO_4 \text{ ppt.} - \text{wt. of filter ash} \times 13.7}{100}$$

To determine the sulphur which remains in the coke, burn 2 grams of coke to an ash, heat the ash with 5 c.c. concentrated nitric acid and about half a gram of chlorate of potash, evaporate nearly to dryness. Add 15 c.c. concentrated hydrochloric acid and digest the solution for 15 minutes. Evaporate to hard dryness. Moisten with 2 c.c. strong hydrochloric acid, add 75 c.c. water and digest for 15 minutes. Filter off the solution, wash with hot water and determine the sulphur in the filtrate as sulphate of barium. The percentage of sulphur found in the ash deducted from the total sulphur in the coal gives the percentage of hurtful sulphur emitted when the coal is burnt.

Phosphorus.—It is only necessary to determine this substance in coke. Take 6.52 grams of coke and burn it to an ash over a Bunsen burner or in a muffle furnace. Fuse the

ash with some sodium carbonate and 0.2 grams of sodium nitrate: more nitrate than this attacks the platinum crucible. Dissolve the fused mass in water, acidify, and evaporate to dryness. Take up with hydrochloric acid and determine the phosphorous by weighing the yellow precipitate of phosphododecamolybdate of ammonium obtained in the usual way. As a check on the purity of the yellow precipitate, the phosphorous in the combined duplicates may be determined by the magnesia method.

Nitrogen.—Kjeldahl's method is the simplest and best Take one gram of powdered coal and place it in an Erlenmeyer's flask with two grams of dried sulphate of copper and 20 c.c. of concentrated sulphuric acid, place a loose cover on top of flask and heat over a Bunsen burner for about half an hour, or till all frothing ceases. Then add 10 grm. sulphate of potash and heat strongly till no unoxidised black particles of coal remain, and the solution is clear. Cool and add water. Close the neck of the flask with a cork in which there are two holes, one for a thistle funnel which reaches to the bottom, the other for a distilling bulb. The outer tube from the latter is connected with a condenser which leads just under a known quantity of deci-normal sulphuric acid contained in a flask. Strong caustic soda solution is poured down the thistle funnel till the contents of the flask is alkaline. Then distil for about an hour; add hot water down the thistle funnel to make up loss and distil for another half hour, by which time all the ammonia will have been driven off and taken up by the sulphuric acid in the receiving flask. Use a drop or two of methyl orange in the deci-normal sulphuric acid as an indicator, for should the red colour change to yellow, thereby indicating that there is not sufficient acid present, there will be a loss of ammonia, thus making the analysis incorrect. When the distillation is complete, the quantity of residual acid is determined with standard ammonia. Each cubic centimetre of the deci-normal sulphuric acid used up is equal to 0.0014 grm. nitrogen.

The ultimate analysis, which gives the percentages of the elements of which the coal is composed, does not convey all the information we require, so we have to fall back on the proximate analysis, which gives us the percentage of moisture, volatile hydrocarbons, fixed carbon, ash and coke. The specific gravity, calorific power and other useful items may also be supplied, which give a good idea of the general adaptabilities of a coal.

Proximate Analysis.

Moisture.—Weigh out 1 gram as quickly as possible into a porcelain crucible, place in a double-walled air bath and dry for an hour, the bath being kept at a temperature as near to

105 deg. C. as possible; the usual range is from 103 deg. to 108deg. C. At the end of this time put a cover on the crucible and place it to cool in a desiccator containing calcium chloride. Weigh rapidly without the cover: the difference between this and the original weight is taken as moisture. The amount of hygroscopic moisture absorbed by the dry fuel in 24 hours should also be noted.

Ash.—The one gram of sample taken for the determination of moisture is heated in a tilted porcelain or platinum crucible with the cover off, so that there can be a free access of air, either over a Bunsen burner or in a muffle furnace; first at a low red heat, which is gradually raised as the carbon is removed. It is better to use the moisture sample than the coke from the determination of volatile hydrocarbons, as this sample can be burnt so much quicker if properly handled. The combustion may be hastened by stirring occasionally with a platinum wire. Care must be taken not to allow fusion, for fear the fused mass should include unburnt carbon. The ash is allowed to cool in a desiccator and weighed. The process is repeated till the weight is constant, the result being returned in percentage. The colour and condition of the ash should be noted. Ferruginous and calcareous ashes are fusible and clinker on the fire bars: aluminous and siliceous ashes remain pulverulent. Sometimes it is necessary to analyse an ash.

Volatile Hydrocarbons.—One gram of powdered coal is placed in a 30 c.c. platinum crucible which is covered with a well-fitting lid so as to keep the air out. The crucible is supported on a platinum or pipe-clay triangle, and exposed to the full flame of a Bunsen burner for seven minutes. The distance from the bottom of the crucible to top of the Bunsen burner should be 17 c.m., the flame from the burner being 16 to 20 c.m. long. To prevent air currents from interfering, place a cylindrical asbestos chimney 15 c.m. long and 7 c.m. in diameter round the flame; by this means a uniform heat is attained, and the lid of the crucible is heated to a visible red. When cooled in a desiccator and weighed, the loss equals the volatile hydrocarbon plus the moisture: the latter is deducted and the result returned in per. cent.

Fixed Carbon.—The residue left after driving off the moisture and volatile hydrocarbons consists of the fixed carbon and ash. The ash is a dilutant, and when deducted from the combined weight of the two, gives the weight of fixed carbon, which is expressed in per cent.

Coke.—All coals do not coke. The residue left by free burning coals after driving off the moisture and volatile hydrocarbons is in much the same form as the powdered coal when first placed in the crucible. A true coke, which consists of fixed carbon and ash, loses its original shape and forms a com-

pact mass of more or less strength. When coke is made in quantity the product is firmer and more coherent than when made on a small scale.

To determine the comparative strength of cokes use Richter's method. The strength is expressed by the multiple of 0.1 gram of powdered quartz that is necessary to mix with 1 gram of coal to weaken the resulting coke sufficiently to enable half a kilo (1.1lb.) to crush it. It is also necessary to examine the physical properties of a coke, its hardness, porosity, etc.

Specific Gravity.—The apparent specific gravity may be determined as follows:—Select a suitable piece of dry coal, free it from dust and suspend by a silken thread from the pan of the balance: determine its weight in the air. Then soak it in distilled water, brush off any air bubbles that cling to the surface, and weigh the specimen again while immersed in water, taking care that it hangs freely. This specific gravity is then found by dividing the weight of the coal in air by the difference in weight of the specimen in air and water. Or about 30 grams of dry and weighed coal may be placed in a 500 c.c. glass jar closed with a screw cap and rubber gasket. In the middle of the screw cap is an opening 0.6 c.m. in diameter, and the cap is sprung so as to make this opening the highest point. Fill the jar with water to a level across the opening in the cap. Draw out 150 c.c. with a pipette, then take off the cap and drop in two or three pieces of coal. Screw the cap on again and take every precaution to see that the cap is screwed to exactly the same mark as before. Water is then added from a burette till the opening in the cap is filled. Taking 1 gram of water to equal 1 c.c., then the apparent specific gravity is the weight of the cubic centimetres displaced by the weight of the coal taken.

To find the actual specific gravity, weigh 3.5 grams of dried and finely pulverised coal and place it in a 50 c.c. specific gravity flask. Fill the flask about 2-5ths full of water; attach to an aspirator and gently boil on a water bath under a partial vacuum for $2\frac{1}{2}$ to 3 hours. The flask is then detached, cooled, filled with water and weighed, and the temperature of the water taken as soon as weighed, so as to enable corrections for temperature to be made.

A knowledge of the strength of a coal is valuable, for if soft, an undue proportion of slack is made while mining; and in subsequent handling and transport, even the lumps become broken up and form much dust. Too much dust in a coal causes an excessive loss of coal through the fire bars, and may prevent the access of air necessary for complete combustion. Should the coal be required for coking, then its soft nature is rather an advantage, as

facilitating its disintegration. A coal which crumbles on exposure to the weather, or which will not readily bear transport must be used near its place of occurrence, and should be used soon after it is mined.

Evaporative Power.—This is determined in Australia by means of Thompson's calorimeter, but for more accurate work Mahler's bomb calorimeter may be used.

Thompson's calorimeter, Fig. 14, consists of a glass cylinder (a) closed at the lower end; (b) is a cylindrical copper vessel called the condenser, open at the bottom and also perforated with holes (b^1) near the open end, the top of the condenser is closed except for a tube with a stop cock (c) at the upper end; (d) is a metal base to which (b) is fixed by means of three springs attached to (d), but not shown in the figure; a series of holes are arranged round the circumference of (d) to facilitate raising the apparatus through the water; (e) is a copper cylinder called the furnace, closed at the lower end only, which fits into a metal ring or seat in the centre of (d). Thirty grains of dry finely-powdered coal is mixed with 10 to 12 times its weight of a mixture made of 3 parts chlorate of potash and 1 part sodic nitrate, which, being hygroscopic, must be kept dry: this mixture gives off enough oxygen to burn the coal without any access of air. The charge is placed in the the furnace (e) and a touch cord, made by passing a piece of string through a saturated solution of nitre or nitrate of lead and dried at 212deg. F., is inserted for about an inch into the material, leaving sufficient outside to burn without touching the mixture while the apparatus is being subsequently dipped under the water. The glass cylinder (a) is filled with water up to the mark, and its temperature noted: the furnace with its charge and touch cord placed in the socket of the metal base (d), the touch cord ignited, and then the furnace is immediately covered with the cylinder (b), the stop cock at the end of the tube being turned off. The whole is lowered into the water and kept there until combustion is completed, hot gases bubbling up through the holes and warming the water. When deflagration has ceased, the instrument is moved up and down to stir the water, and the stop cock is opened, when water fills the vessel. The temperature of the

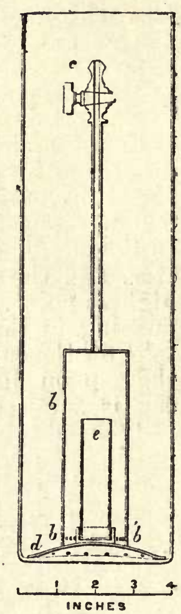

Fig. 14.
Thompson's
Calorimeter

water is again taken, the highest reading being accepted. The temperature of the water at the commencement should be as near 60deg. F. as possible: if too hot, the gases are not properly cooled before they escape. If the test is properly conducted, the contents of the copper furnace ought to dissolve out in water and only leave a white ash; but if there is any black unburnt coal left, the ash and what remains of the coal are collected, weighed and ignited in a platinum crucible, and the loss deducted from the amount of fuel taken. A British thermal unit is the quantity of heat necessary to raise 1lb. of water one degree F. when at or near 39deg. F. It requires 967 B.T.U. to convert one unit of water at 212deg. F. into steam at that temperature: in other words, the latent heat of steam is 967deg. F. If each grain of fuel is burnt in the midst of 967 grains of water, then since 30 grains of fuel are taken we require 967 × 30, or 29,010 grains of water, so the glass cylinder is graduated to hold this quantity. By deducting the original temperature of the water in the cylinder from the temperature after the experiment, we do not obtain the true heating power of the fuel, since the copper cylinders absorb a certain amount of heat, and some more is lost by the imperfect absorption of heat by the water. By careful comparative tests with the bomb calorimeter it is found that a fair correction is to add one-tenth of the increase of heat to the difference between the temperature before and after the test. For example—

Temperature of water after experiment	71 deg. F.
Temperature of water before experiment	60 deg. F
	11 deg. F.
Plus 1-10th of 11 deg.	1.1 deg. F.
Evaporative Units	12.1 deg. F.

which signifies that 1lb. of coal would evaporate 12.1lb. of water previously heated to 100 deg. C. or 212 deg. F. The calorific power is better expressed in evaporative units than as British thermal units, as the latter would give a large and unwieldy figure.

When the results of an analysis are obtaned, one should be able to interpret them so as to determine the value of the fuel for the purpose required.

Volatile Matter.—The amount and quality of the volatile combustible matter decides whether the coal is suitable for the manufacture of illuminating gas or not. There should not be too much or too little volatile hydrocarbons in a coal required for coking, otherwise the coke will be too spongy or the walls of the cells will be too thick. Coals that give off too much gas

ignite easily, burn with a long yellow flame, and form much soot, which makes it objectionable for railway and naval uses. Besides volatile hydrocarbons, the volatile matter will contain any moisture retained by clay present which is not expelled at a temperature less than that necessary to decompose the coal; it will also contain some sulphur, and if carbonate of lime is present, carbonic dioxide.

Fixed carbon is the chief combustible constituent in coal, for although an equivalent weight of the volatile hydrocarbons when properly burnt will evaporate more water than the fixed carbon, yet so much of the former is lost by improper furnace construction and careless firing, that the steaming value of a coal is in proportion to its percentage of fixed carbon. The nature of a coal is not told by its percentage of fixed carbon, but by its fuel ratio, as mentioned elsewhere.

Moisture.—Hygroscopic moisture in a fuel increases its weight for transport; each per cent. of moisture means 22.4lb. less fuel for each long ton of coal. If the fuel is sold by weight, and no deduction is made for the water absorbed by it then such water is paid for as fuel. Moisture is further harmful inasmuch as it abstracts a certain amount of heat in order to evaporate it; but, on the other hand, it is doubtful whether water should always be looked upon as a non-fuel, for in many cases its elements become disassociated, leaving the hydrogen available for fuel purposes, as in the manufacture of water gas when steam is passed over red-hot coke.

Though a coal may appear perfectly dry, it may still contain a considerable quantity of water. That which is lost by the coal when exposed to ordinary atmospheric conditions is known as "pit water," but that which it still retains is known as "hygroscopic moisture." When the hygroscopic moisture is driven off, the coal becomes more tender and friable. The contents of water in a coal is affected by the size of the coal. When fine it contains less pit water, but more hygroscopic moisture than when lumpy.

Ash is a dilutant to a fuel, and by adding to its weight increases cost of freight and is paid for as if a fuel. One per cent. of ash is equivalent to nearly 22½lb. in a long ton. If excessive, it gives more work to stokers, and carries away a certain amount of heat through the fire bars; it also hinders complete combustion by entangling particles of fuel. If a coking coal, the ash tends to weaken the coke, and may have to be taken into consideration when calculating the slag of a blast furnace. If the ash is readily fusible, it may form clinkers on fire bars, and obstruct the free passage of air. A rough idea of the percentage of iron in an ash may be obtained by noting the colour of it; iron is objectionable, since it makes the ash more fusible and increases its tendency to

clinker. For domestic purposes, where the temperature is low, the quantity of an ash is of more importance than its fusibility.

The percentage of ash may vary from two to thirty-six, but the best fuel should not contain more than 7 per cent., the medium more than 14 per cent., while that which goes over 14 per cent. is looked upon as poor. The proportion of ash is somewhat more in slack than in lump coal from the same seam.

When iron pyrites occurs in a coal, since 3 atoms of oxygen replace 4 atoms of sulphur, the weight of the ash is less than the weight of the mineral matter in the coal by 5-8ths, the weight of the sulphur of the pyrites. Corrections for this, however, are not made in proximate analysis.

Nitrogen in a state of chemical combination is always found in coals, its percentage generally being between one and two per cent.

Sulphur.—This element generally occurs in coals as iron pyrites, but may also be present as gypsum, or even baryte It is the sulphur of the pyrites that is hurtful for most economic purposes, for it is readily given off as sulphur dioxide, or sulphuretted hydrogen, while the sulphur of gypsum and baryte is fixed in the ash. When present in gas or household coals, the sulphur tarnishes silver and silver prints; when used for boilers it corrodes iron and copper, and it is bad for forge work. Pyrites is also disliked by coal miners, for the nodules are harder to work out than coal, and pyrites is often credited with being the cause of spontaneous combustion in coal.

Phosphorous.—This has been found in the ashes of coals combined with one or more of the bases present: as this tends to pass into pig-iron when smelting iron ores, the absence of phosphorous is an important matter when the iron is required for the Bessemer process of steel-making.

Coke is the residue left after driving off moisture and volatile matter: it is therefore richer in ash than the coal from which it is made. All the sulphur is not driven off by coking, so it is often advisable to get rid of as much of this and also of the ash present in the original coal as possible by washing, since the presence of these substances may have an important bearing on the production of a coke for blast furnace or foundry purposes. Coke has, weight for weight, more carbon than the fuel from which it was obtained; and also a higher calorific value. Coal loses on an average about 1-3rd of its weight in coking, and increases about 1-10th in bulk.

The specific gravity of a coal is important, and may be due either to combustible matter or impurities that form ash. The specific gravity of anthracite is greater than that of bituminous coal, and in consequence it takes up 10 to 15 per cent. less

bulk for the same weight, and so occupies less bunker room on board ship. If the increased specific gravity of a coal is due to non-combustible material, then, of course, it becomes deleterious. By means of the specific gravity of a coal, we can ascertain the weight of a cubic foot of it, or how many cubic feet go to the ton, and how many tons per acre an inch in thickness represents. A seam of coal having a specific gravity of 1.3 will contain about 130 tons per acre for every inch in thickness. Allowing for moisture, pillars and waste, 100 tons per acre per inch is a close approximation to the probable yield. We must distinguish between the apparent and the actual specific gravity: the former is the specific gravity of a piece of coal, the pores of which are not filled with water; the latter is the specific gravity of the coal with all the air driven out.

By specific gravity is meant the weight of a body as compared with the weight of an equal bulk of the standard body which is reckoned as unity. Pure water at 60deg. F. is taken as unity. A cubic foot of distilled water weighs 62.321lb.

Heating Power of Coals.

In Great Britain and the United States of America the unit of heat adopted is the British Thermal Unit (B.T.U.) This is the amount of heat required to raise the temperature of one pound of pure water through one degree Fahrenheit at or near 39.1 deg. Fahr., the temperature of maximum density of water.

On the Continent of Europe the French Thermal Unit or calorie is employed, which is the quantity of heat required to raise the temperature of one kilogramme of water one degree Centigrade, at or about 4 deg. C. One French calorie equals 3.968 B.T.U., and 1 B.T.U. equals 0.252 calories. According to the determinations of Favre and Silbermann, the complete combustion of a kilogramme for calories, or a pound weight for B.T.U. of the following substances develop the accompanying heats:—

*H to H_2O	34,462 calories = 62,032 B.T.U.
C to CO_2	8,080 calories = 14,544 B.T.U.
CO to CO_2	2,403 calories = 4,325 B.T.U.
S to SO_2	2,220 calories = 3,996 B.T.U.

From these we are enabled to calculate the theoretical values of any fuel from its chemical composition, due allowance being made for the hygroscopic water present in the fuel. †Dulong

*Chemistry, Theoretical, Practical and Analytical, as applied to the Arts and Manufactures, Div. IV., page 896 (London).

†Poole (H). The Calorific Power of Fuels (New York) 1898.

stated that the heat generated by a fuel during combustion was equal to the sum of the possible heats generated by its component elements, less that portion of the hydrogen which might form water with the oxygen of the fuel. The formulæ he gave were:—

$X = 8080C + 34500\ [H - (O \div 8)].$

$X^1 = 14500C + 62100\ [H - (O \div 8)].$

in which X = the heat of combustion sought in calories.

X^1 = the heat of combustion sought in B.T.U.

C = percentage of carbon in analysis of the fuel.

H = percentage of hydrogen in analysis of the fuel.

O = percentage of oxygen in analysis of the fuel.

When hydrogen and oxygen exist in a compound in the proper proportion to form water (i.e., 1 pt. of hydrogen to 8 pts. of oxygen), these constituents have no effect on the total heat of combustion. It follows that only the surplus hydrogen above that required by the oxygen is to be taken into account.

$H - (O \div 8)$ = the quantity of hydrogen in the analysis of the fuel less that supposed to form water with the oxygen. In computing the total heat of combustion it is convenient to substitute for the hydrogen the quantity of carbon which would give the same quantity of heat, and this is done by multiplying the weight of hydrogen by $62.0322 \div 14{,}500 = 4.28$ making the formula:—

$X^1 = 14{,}500\ (C + 4.28\ [H - (O \div)].$

The theoretical evaporative power of 1lb. of the fuel in lbs. of water evaporated from 212deg. F. is:—

$E = X^1 \div 966.$

966, or rather 966.1, is the number of B.T.U. required to evaporate 1lb. of water at boiling point under a pressure of one atmosphere. This corresponds to 536.7 calories, which are necessary to evaporate one kilogramme of water under similar conditions.

Dulong's formula does not allow for the heat due to sulphur; this, however, in an ordinary coal is a very small percentage, and will only apply to that sulphur not left in the ash, so it would have very little effect on the toal. If desired to allow for the sulphur, then the formula would read:—

$X = 8080C + 34{,}500\ [H - (O \div 8)] + 2220S.$

where S = the available sulphur in the fuel.

The calorific power computed by formulæ from the ultimate analysis of a fuel is not quite correct when compared with the results of calorimeters, for errors are apt to creep into the analysis; various authorities differ slightly in their

determination of the heat units developed by carbon, hydrogen and sulphur when completely burnt; also the results of different formulæ vary. The difference between the calorific power calculated from Dulong's formula and that obtained by Mahler's calorimeter in careful hands is not so great as is generally thought. N. W. Lord and F. Haas* made several tests, and the results were so uniform that they could not be credited to accident. "The maximum difference between the heat calculated from the elementary analysis and the heat developed in the bomb is 2 per cent. of the total calculated heat, the minimum difference 0.1 per cent. The posible error of an ultimate analysis may be placed at 0.5 per cent. on carbon, and 0.2 per cent. on hydrogen, especially with coals as high in ash and sulphur as are many of the samples included in our tests. This would lead to an error of about 108 units, or nearly 1.4 per cent. on the calculated heat value."

The ultimate analysis of a coal is much more difficult to make than the calorimetric determination, so attempts have been made to ascertain the relation between the fixed carbon obtained by the more rapid proximate analysis and calorimetric tests. These are naturally not so correct as when calculated from the ultimate analysis. W. Kent† states: "Knowing the percentage of fixed carbon in the dry coal free from ash, we may in the case of all coals containing over 58 per cent. of fixed carbon predict their heating value within a limit of errors of about 3 per cent. . . Below 50 per cent. of fixed carbon the law apparently does not hold good, as shown by the tests of some lignites." He then gives the following table of approximate heating-values of coals, which was constructed from the average curve from Mahler's tests on European coals:—

Per Cent. of Fixed Carbon in Coal. Dry and Free from Ash.	Heating Value. Calories.	British Thermal Units.
97	8200	14,760
94	8400	15,120
90	8600	15,480
87	8700	15,660
80	8800	15,840

*The Calorific Value of Certain Coals as Determined by the Mahler Calorimeter (T. Am. I.M.E., Vol. XXVII., p. 259) [1897].

†Tests of the Heating Power of Coals. Mineral Industry, Vol. 1 (1892), p. 97.

Per Cent. of Fixed Carbon in Coal. Dry and Free from Ash.		Heating Calories.		Value. British Thermal Units.
72	..	8700	..	15,660
68	..	8600	..	15,480
63	..	8400	..	15,120
60	..	8100	..	14,580
57	..	7800	..	14,040
54	..	7400	..	13,320
51	..	7000	..	12,600
50	..	6800	..	12,240

Lord and Haas found that the results of their work did not correspond to the above figures. The theoretical heating value of coals varies between about 7000 and 16,000 B.T.U., depending on their nature.

In order to completely burn one pound of carbon, 2.66lb. of oxygen are necessary; but as air, the usual source of oxygen, only contains 21 per cent. of that element, it follows that 12.66lb. of air must be provided to oxidise 1lb. of carbon.

Since a calorimeter burns all the fuel, it gives a better result than is possible in a boiler, for a boiler does not take all the heat out of the gases generated by the fuel: then there is always an excess of air supplied to the fire which carries away quantities of heat up the stack; also all the fuel is never burnt in the fire box of a boiler, therefore some of the heat is not developed. It will thus be seen that the value of a fuel for heat-producing purposes depends largely on the efficiency of the boiler, and a fuel that will do good work in one class of boiler may not come up to expectations in another; if, however, the true heating power of a fuel is given as ascertained by a calorimeter, it serves, other things being equal, as an indication of the relative value of different fuels. There are yet other points to be considered, such as the skill of the stoker, and the size of the fuel. In the latter case, lump coal, having the same thickness of bed on the fire bars as that given to slack, will permit more air to pass through it than the slack, and this excess of air lowers the temperature. If, on the other hand, an insufficient supply of air is admitted, then there is a loss of heat by incomplete combustion. Some boilers are so constructed that the proper amount of air cannot be regulated and consequently a superior coal burnt in such an apparatus may give a worse result than that of an inferior coal burnt in a properly constructed boiler. It is not possible to arrive at the value of a fuel by analysis alone. Analysis may show the heating power of a fuel, the moisture, ash, volatile matter and fusibility of the ash: but it does not give

an idea in figures of the injurious effect of the moisture and ash, what volatile matter is wasted in a given furnace, the effect of the size of coal and what heat is lost by a low efficiency of a boiler or improper manipulation of the fire.

The unavoidable losses of heat may be put down to the heat lost by converting the moisture contained in the coal into steam, also that in the air used in burning it, and in addition heating the steam thus formed to the temperaure at which it leaves the stack. Then there is the heat necessary to raise to the stack temperature, the carbonic acid gas formed by burning the carbon, the sulphurous acid gas from burning the sulphur, the nitrogen of the air after the oxygen has been used up, and the excess of air admitted into the furnace. Further losses are made through the heat of the ashes removed from the ashpit, as well as from the carbon remaining in the ashes, and through radiation from boilers and walls, which may be reduced by careful construction and covering, but can never be entirely eliminated. The losses that may be more or less avoided are:—

1st. Those due to incomplete combustion as shown by the presence of smoke and carbon mon-oxide in the flue gases, and unconsumed coal in the ashes. The loss resulting from smoke is absolute, it is not only so much fuel gone to waste, but has required a certain amount of heat to raise it to the necessary temperature to escape with the flue gases: the actual waste is, however, comparatively insignificant and not nearly so much as is generally supposed. The loss of efficiency due to the escape of carbon mon-oxide on account of 1lb. of carbon is the difference between 4400 B.T.U. when burnt to carbon mon-oxide, and 14,650 B.T.U., when one pound of carbon is burnt to carbon dioxide, or 10,100 B.T.U. more, i.e., 69.28 per cent. The loss of coal in the ashes may be due to the original small size of the coal, or the subsequent decrepitation, which results in more or less of it dropping through the grate. This may be somewhat reduced by skilful manipulation of the fire. Small quantities of unconsumed hydrogen, or moist gas, may also escape up the stack.

2nd. Loss from excess of air. Air is composed of:—

	By volume.	By weight.
Oxygen	21.3	23.6
Nitrogen	78.7	76.4
	100.0	100.0

To burn 1lb. of the following substances requires the corresponding weight or volume of air:—

	Air in lbs.	Air in cub. ft. at 62deg.
Hydrogen to water	33.9	444
Carbon to carbon mon-oxide	5.7	75
Carbon to carbon dioxide	11.3	148
Carbon mon-oxide to carbon dioxide..	2.41	32
Marsh gas to water and carbon dioxide	16.9	222
Sulphur to sulphurous acid	4.25	56

For approximate calculation of the weight of air required for combustion of coal the following formula may be used:—

$$\text{Weight of air} = 12C + 34\,(H-(O \div 8)).$$

where C = carbon, H = hydrogen and O = oxygen in the fuel. The $O \div 8$ gives the weight in pounds of hydrogen rendered inert by the oxygen of the fuel, and which therefore has to be deducted, for—

$$H_2 : O :: 2 : 16, \text{ therefore } H : O :: 1 : 8.$$

When we consider that the oxygen in the air is mixed with nearly four times its volume of nitrogen, which tends to separate it from the fuel, we cannot expect all the individual atoms of oxygen to unite with their proportion of carbon or hydrogen in the fuel, so we have to add an excess of air. This excess will vary greatly in different cases from between 50 to 300 per cent. The loss due to excess of air will depend on the quantity of unused air that becomes heated and escapes, and also upon the amount of moisture in the air.

3rd. The loss resulting from too great a temperature of the escaping gases is one of the most important factors in fuel efficiency. It is largely due to the design of the boiler, etc.; but is also influenced by the air supply and rate of combustion. To keep the air supply as low as possible so as to obtain the greatest efficiency, requires the greatest care and attention on the part of the stoker; the fire would be apt to be dull and there would be practical difficulties in maintaining it under varying conditions of demand.

4th. Loss of heat by removing ashes at too high a temperature. This can be greatly reduced with care.

5th. Loss by radiation. This may be lessened by increasing the thickness of walls and covering all exposed portions of the boiler.

A thin fire increases loss due to excess of air, but decreases that due to smoke and incomplete combustion. On the other hand, a thick fire reduces the excess of air, but increases the loss due to smoke and escaping combustible gases.

Different kinds of coals give best results when burnt under conditions suited to them, consequently when several classes of coal are being tested with a particular boiler, though the comparative tests may be satisfactory so far as that boiler is

concerned, yet some of the coals may not show to their best advantage, simply because the boiler is not suitable for them. To get the best effect out of coal, it must be burnt at a certain rate per square foot of grate per hour. In order to burn some coals to the best advantage the grate area would be so large as to put it out of the question for certain purposes, such as locomotive work. Two coals may have the same theoretical heating value, and yet the useful effect for steaming purposes may be different, according to the ratio of fixed carbon to volatile hydrocarbons. Anthracite disintegrates slowly; semi-anthracite quicker, while with bituminous coal it is almost instantaneous.

Different coals should be compared under the conditions they are to be used, so that they shall be subject to similar losses; otherwise it is impossible to make suitable allowances, as in the case of locomotive tests for variations in grades, curves, loads, number of vehicles, length of train, speed, stoppages, weather, quality of water, individuality of the engine-driver, stoker, etc.

Coals may sometimes be mutually improved by blending them in proper proportions. For instance, with two coking coals, one may not contain sufficient volatile matter to fuse properly, while another may contain so much as to make the coke too porous. For steaming purposes one available coal may burn too fiercely and have too much volatile hydrocarbon, while another may burn too sluggishly; it may be cheaper to mix these than to obtain a coal more suitable in itself from a distance. The gas from one coal may help to keep the other alight, and the coking properties of another may prevent much small coal from falling between the fire bars.

To ascertain the calorific power of a coal when burnt under a boiler, one must determine the quantity of water evaporated in pounds by one pound of fuel. The number of calories lost in the gases, by radiation and drawn with the ashes, must also be known. The total quantity of heat developed by the combustion of the fuel must be determined in order to be able to calculate the percentage of heat usefully employed. J. Holliday* says, draw all the fuel used to heat the water in the boiler to 212 deg. F., and light up the fresh fuel with 20lb. dry wood; this kindling wood need not be taken into consideration, as the heat developed by it is more than balanced by the loss of heat from the boiler during the operation of drawing the fire. Each charge of fuel is carefully weighed—say 500lb. of coal for each 25 sq. ft. of grate area—carefully mix the fuel beforehand to secure uniformity, and note how often the fur-

*Boiler Experiments and Fuel Economy (Min. and Pro. I.C.E., Vol. xcii., page 336, [1887-88.])

nace is charged, to show the comparative labour for each kind of fuel. Carefully measure the quantities of fuel and water (the latter in a tested water meter), consumed per square foot of fire grate per hour, also the heating surface of the boiler. A certain proportion of the fuel drawn from the fires at the end of the trial is assumed to be good, and its weight deducted from the total fuel supplied. The level of the water in the boiler should be the same at the end as at the beginning of the test. The feed water should be kept as far as possible at the same temperature to avoid subsequent corrections, and the feed pump should work regularly. A trial should continue for at least a day on account of irregularities that may cause errors. For ultimate comparisons of fuels, the results should be corrected for moisture in the steam and in the fuel. Other tests are necessary to ascertain whether the proper quantity of air has been admitted for combustion of the fuel, determined by the chemical composition of the gases as they leave the boilers.

We must remember that coal is seldom burnt as carefully in practice as it is for tests. The engineer wants to get as much steam as possible out of his boiler, and does not always give the coal time to burn properly or economically, so when comparing results, we must consider whether the coal is to be made to fit the work, or the work to fit the coal. Also it must be borne in mind that the returns from careful tests are no criterion as to the work the coal will do when subject to careless everyday usage.

Size of Coal.

For commercial purposes, coal is classified according to its size, but all collieries do not produce the same classes. Shovel-filled, or "shandygaff," is the run-of-mine coal as broken at the faces. Fork filled, is coal filled into skips at the face with a fork: such a fork has about 10 tines, say an inch and a quarter apart. Fork-filled coal has much of the slack separated out, which slack is shovelled on one side till required by the colliery owners. The miners are not paid directly for this slack, but as compensation they are paid at a higher rate for fork-filled coal. Since this might encourage some men to fill in an undue proportion of slack with the forked coal, in order to increase their tonnage, the allowable percentage of slack in fork-filled coal is limited to ten per cent. The weighmen, by experience, can soon tell if this is exceeded, so if the skips of one man show that he is trying to gain a point, they are put on one side and tested; if the percentage of slack has been exceeded then that miner has to seek work elsewhere. Large, lump, round, or screened coal is that which passes over bars placed $\frac{3}{4}$in. apart; though at some col-

lieries the distance apart is greater. It is cleaner than fork-filled coal, as the slack has a better opportunity of being separated. Lump coal is better for transport, for although it breaks up to a certain extent during handling, still the proportion of fine coal is not excessive. Lump coal has to be broken up before being used, and in so doing a certain amount of small coal is produced, so some users prefer unscreened, as not only being cheaper, but saving time and trouble in breaking up the lumps. Slack, small, or fine coal are synonymous terms for coal that passes through the screens. Nuts is a name given to coal that passes between screen bars ¾in. apart, and over screens with 3-16in. mesh; it is chiefly made for mechanical stokers. "Duff" is the coal that is left after the separation of the large coal and nuts; it is largely used at some collieries for converting into coke. Bunker coal may be unscreened, but more often it is small.

CHAPTER III.

Irregularities in Coal Seams.

Coal seams may have their regularity interfered with by causes prior to their formation; while they were being formed; or subsequent to their formation. The first case is illustrated by irregularities in the original floor. The second by washouts in the seam due to ancient creeks; also by partings and bands due to floods and submergence. The third case is illustrated by rolls, which may thin and thicken the coal locally, due to earth stresses; also by faults and dykes, or laccolites. The throw of a fault may be insignificant, or may be over two hundred feet, necessitating long stone-drifts, or even new shafts, and a material alteration in the laying out of a mine. In the case of intrusion by igneous rocks, the coal may be coked or cindered over a considerable area. The difference between coked and cindered coal is that the former retains about two or three per cent. of volatile hydrocarbons, while the latter is not much better than an ash. Cindered coal, besides being worthless, has a further disadvantage, inasmuch as it is often harder to work than the dyke rock itself. This dyke rock in the Southern coalfield, so frequently met with in some of the collieries, is generally considered to be a dolerite, but it is so altered, and is usually bleached by the coal, that it has not yet been properly determined.

In some districts coal seams are much disturbed by faults. As seams are generally more horizontal than vertical, coal miners look for the displaced portion overhead or underfoot, and call it an up-throw or down-throw accordingly. Such faults may be divided into two sorts, normal and reversed. The former is shown in Fig. 15, where that portion of the seam on the hanging wall side of the fault is lower down than that on the footwall side. If the fault has a flat angle, it may have the effect of causing a considerable area parallel to the strike of the fault to be wanting in coal, as at (a). With a reversed fault, as shown in Fig. 16, the seam on the hanging wall side of the fault is higher than that on the footwall side; the seam overlaps itself, so that if a borehole be sunk through the seam near the fault, it would appear as if there were two

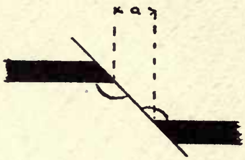

Fig. 15.
Normal Fault.

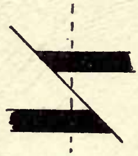

Fig. 16.
Reversed Fault.

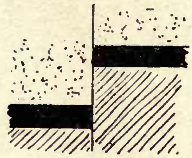

Fig. 17.
Vertical Fault.

Fig. 13.
Normal Fault, with sides dipping towards each other.

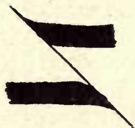

Fig. 19.
Reversed Fault, with sides dipping from each other.

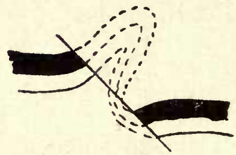

Fig. 20.
Sides dip away from each other.

Fig. 21.
Sides dip in same direction upwards.

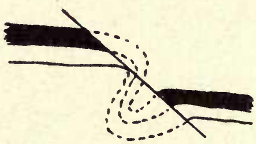

Fig. 22.
Sides dip in same direc tion downwards.

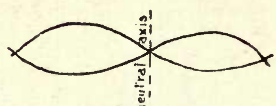

Fig. 23.
Variations in throw of a Fault in folded strata.

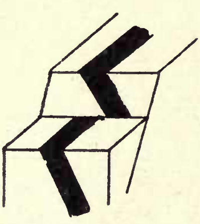

Fig. 24.
Apparent Heave due to Throw.

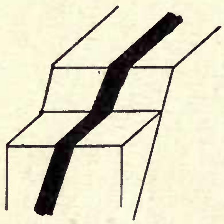

Fig. 25.
Throw does not show apparent Heave.

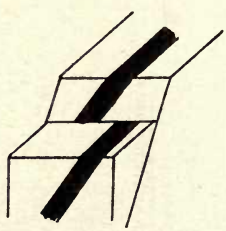

Fig. 26.
Apparent Heave due to Throw.

seams. It is naturally an important matter to know whether to search for the lost portion of a seam above or below the line where it is lost. Normal faults are of more frequent occurrence than reversed faults. A rule to find the lost portion of a faulted seam, when the fault is a normal one, is to follow the larger angle made by the intersection of the seam with the fault. Thus in Fig. 15. if the fault is first met with in the roof look for the lost portion under foot on the other side of the fault; or if the fault is first met with in the floor, search for the lost portion overhead. With vertical faults (Fig. 17), this rule is indefinite. Unfortunately one cannot tell by merely observing a fault at the point where it is struck, whether it is a normal or reversed fault. If the latter, then this rule does not hold good.

Sometimes a seam and adjoining beds are bent up on one side of a fault and down on the other (Fig. 18), in which case they wedge out, instead of being cut off straight. Miners take this as an indication of what direction to go, in order to find the lost portion of a seam, and follow the bent end near the fault; but if the fault has taken place in a fractured fold, as in Figs. 20, 21, and 22, even though normal, or if it is a reversed fault (Fig. 19), this indication may lead one astray. The safest rule is to note the relative positions of the rocks faulted when they are sufficiently distinctive in character. (Fig. 17). Here, again, one must be cautious, for beds may be locally thickened or thinned out so that they are not recognised; or may be confounded with other, but somewhat similar, beds. If the sedimentary rocks contain an eruptive among them, it cannot be relied on too much, on account of its liability to irregularities.

A series of parallel faults may cause the seam to outcrop at the surface several times, which may at first lead people to think each outcrop is a separate seam.

To distinguish between a true reversed fault and a fold fault; fold faults are only found in regions of folding accompanied by other phenomena, such as harmonic second class folds, cleavage, etc., and they always have the same strike as the undisturbed folds. Fold faults are more frequent than reversed faults, which are only local in character, and have no relation to folds of the strata. With fold faults the plane of dislocation is generally steeper, and always dip in the same direction as the strata, which is not necessary with true faults.

A fault plane may be occupied by broken country or clay, or a dyke rock. In either case the coal near a fault is generally inferior to that further from it, being broken and dirty, or if near a dyke coked or cindered. A fault does not have the same displacement all along its course: its greatest dis-

placement is generally about the centre, and it dies out into nothing at the ends; or if the fault cuts across folded country, there may be neutral points along its strike where there is no displacement. (See Fig. 23).

Where a seam is tilted up at an angle, and a fault cuts across its strike the broken portions of the seam on the same horizon may appear to have a lateral displacement. The seam may really have been heaved to one side, or the difference in position may be due to a throw. The effect of variations in the dip and direction of a seam that is thrown, on the lateral position of the displaced parts when worn down to the same level, may be seen by referring to Figs. 24, 25, and 26. The probability is that pure throws and pure heaves seldom occur, but that most faults are a combination of the two, in which the effect of one may be more pronounced than the other.

CHAPTER IV.

Ventilation.

The ventilation of a colliery is of vital importance to those working underground. Air is made up of approximately 79 per cent. of nitrogen by volume and 21 per cent. of oxygen; but in nature it also contains a small amount of moisture and from 0.03 to 0.04 per cent. of carbon dioxide. A cubic foot of air is 773 times lighter than water. At 32deg. F. it weighs 0.080721b.: it expands 1 volume in 460 for every degree Fahrenheit.

1000 cubic ft. of air weighs 81lbs.
1000 cubic ft. of CO_2 weighs 124lbs.
1000 cubic ft. of CH_4 weighs 45·22lbs.

The amount of oxygen in the air diminishes more rapidly in coal than in metal mines, as there is a larger surface exposed to oxidation in proportion to the ventilation current. The amount of air required by law in New South Wales is 100 cubic feet of air per minute for each man, boy and horse.

Air should not contain less than 0.5 per cent. of the normal amount of oxygen.

A man inhales about three times as much air when in motion or at work than when at rest.

Carbon dioxide (CO_2) has neither taste, colour nor smell. Among miners it is known as "choke damp" or "black damp," but in mines the gas is never pure, and is said to have a smell; this, however, is due to the presence of hydrocarbons. According to most authorities air containing more than 0.1 per cent. of CO_2 is unfit for respiration; the effects of it, however, are not very noticeable until the proportion reaches 3 per cent., when the depth of respiration is slightly increased. At 5 per cent. there is a marked panting while at rest. At 7 to 8 per cent. there is great oppression and painful panting. With 10 per cent. the difficulty becomes severe, while a slight increase of CO_2 produces unconsciousness and death. When the air extinguishes a lighted candle one should take it as an indication that the air is unfit to support life. The amount of CO_2 that is sufficient to extinguish a flame depends partly on the nature of the illuminant and partly on the amount of

oxygen present, for an increase of CO_2 displaces a certain percentage of oxygen; from 5 to 14 per cent. of CO_2 is said to extinguish a candle flame, and 58 per cent. will put out a hydrogen flame. A man at work will produce 2.10 cubic ft. CO_2 per hour. Choke damp, due to the oxidation of coal, may continue to be given off long after any fire damp has been drained away. It may also be formed by underground fires with free access of air. Its presence is generally determined by the failure of lights to burn well; it may also be tested by aspirating air through lime or baryta water.

Carbon dioxide being incapable of supporting life is irrespirable, the arterial blood rapidly becomes venous; besides, it is in itself a narcotic poison. A man who finds himself in an atmosphere containing too much CO_2 breathes deeper and more frequently, the slightest exertion causes panting, he gets a headache with great pressure in the temples, becomes giddy, drowsy, loses muscular power; there is profuse perspiration and nausea, singing in the ears and a pungent sensation in the nose, and finally insensibility, culminating in death, if the sufferer is not removed and resuscitated. It must be noted that death need not result, even though a man has been unconscious for some time, if he is removed to fresh air and artificial respiration be resorted to.

Carbon monoxide (CO) or "white damp," is a very insidious poison. Its presence in collieries is due to incomplete combustion during fires or explosions. It has a sweet, delicate odor: it does not extinguish lamps as it is inflammable, but it is not explosive until the proportion of CO is over 15 per cent.

Under ordinary conditions of breathing the oxygen of the air is absorbed by the blood and forms an unstable chemical compound with the red colouring matter (hæmoglobin) of the corpuscles, which is utilised by the body. Carbon monoxide is poisonous, its poisonous character being due to its chemical avidity for hæmoglobin, which is stated to be 200 to 250 times greater than that of oxygen. As soon as the blood is saturated with CO, which forms carboxy-hæmoglobin, and is very stable, it ceases to take up any further oxygen from the air. Experiment shows that only 60 per cent. of inhaled CO is actually absorbed by the blood. Bad symptoms are produced where only 0.05 per cent. is present in the air, while death results with from 0.3 to 1 per cent. When CO accumulates in the blood to 30 per cent., it causes giddiness, swelling of the veins of the forehead, palpitation, shortness of breath and weakness of sight. At about 50 per cent. a man begins to lose power over his legs, he becomes unconscious, and at 79 per cent. death occurs. As helplessness comes before unconsciousness, a suf-

ferer should take warning from the preliminary symptoms. When 0.06 per cent. CO is present in the air it will cause the blood to accumulate 30 per cent. after an hour and a half: 0.1 per cent· causes helplessness in about an hour: with 0.3 per cent. the blood will be saturated in half an hour; with one per cent. saturation of the blood takes place in five or six minutes. Characteristic of death by carbon mon-oxide is the rose-red life-like appearance of the corpse; before death, however, the skin is dusky except where more or less extended patches of bright colour make their appearance on the body, while the lips and extremities are blue. After death the eyes are bright and staring, the pupils dilated, and the jaws fixed. It takes a considerable time to get rid of carbon mon-oxide from the blood, which is probably done by converting it into carbon dioxide; if a man has absorbed much into his system, resuscitation may be impossible. The removal of carbon mon-oxide from the blood proceeds five times as rapidly with pure oxygen as with fresh air, according to Dr. Haldane*. The amount of oxygen to be inhaled by a person necessarily depends on the quantity of carbon mon-oxide absorbed. Dr. Haldane recommends the breathing of oxygen for an average of 10 minutes, which would consume about two cubic feet. A rough method of obtaining oxygen in case of emergency is to heat potassium chlorate, which readily yields up its oxygen.

Mice are sometimes kept at mines for the purpose of testing for CO, as they are peculiarly susceptible to its poisoning effects, since a mouse respires 20 times quicker than a man, and consequently exhibits symptoms of blood saturation more rapidly. The white variety used for pets are generally kept, as they are more delicate than the ordinary mouse and are more readily observed with a bad light. As soon as a mouse becomes incapable of motion, due to the presence of carbon mon-oxide, the air should be considered dangerous to man.

After damp is a mixture of the gases resulting from an explosion, and consists of carbon dioxide, carbon mon-oxide, nitrogen and water. There are more deaths due to suffocation and poison by carbon mon-oxide in after damp than to injuries by violence and burns the result of an explosion. A man suffers severely when recovering from poisoning by after damp, and may succumb days afterwards from the effects. Drs. D. Macaulay and L. G. Irvine† lay great stress on the fact that "gassing" is a shock to the system, and that shock is characterised by three important symptoms. First, weakening of the heart's action;

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*Causes of Death in Colliery Explosions, and Underground Fires. London, 1896. By authority.

†Safety Measures in Mining. (Joul. Chem. Met. and Min. Soc. of South Africa, Nov., 1905.)

second, general exhaustion of the nerve centres; third, lowering of the body temperature. Under these conditions the popular remedies for all cases of insensibility, viz., treating externally with cold water and internally with whisky, is radically wrong. The lowering of the temperature of the body is not only due to shock, but also to the fact that CO and CO_2 directly affect the oxygenation of the blood, so every effort should be taken to raise the temperature of the body. As alcohol has been proved to increase shock, its use should also be avoided. In every case of gassing, where the act of swallowing is voluntarily possible, an emetic should be at once administered. The advantage of emptying the stomach, and of emptying the lungs of mucus and of any unabsorbed gas in their ultimate recesses, which the act of vomiting does more effectively than any voluntary effort, more than counterbalance any momentary depressing effect of the emetic. In every case of gassing, which is so profound as to cause deep coma and arrest the breathing, artificial respiration must be started immediately and persevered in so long as there are any indications of life.

Methane, light carburetted hydrogen, marsh gas or fire damp.—Strictly speaking, fire damp is a mixture of gases, the largest proportion being CH_4, with which is associated other hydrocarbons, such as olefiant gas (C_2H_4), hydrogen, carbon dioxide, oxygen, and nitrogen. This gas is held in the pores of the coal in more or less high tension, from which it issues with a hissing noise. Blowers are more or less steady discharges of gas from coal for a long time; in some places the pressure from blowers has been measured and found to be as high as 900lbs. per square inch. In such cases of high pressure a fall in the barometer can have but little influence, for supposing the fall was equal to one inch of the water gauge, which would be exceptional, this only means 5.2lb. per square foot or 11-288ths of a pound on the square inch, so the effect on the gas issuing from the coal can only be very trifling. Atmospheric changes, however, affect fire damp in goaves. We occasionally hear of cases where death has occurred in houses due to an escape of gas. Methane is not an inherent poison; it is simply a non-supporter of life, causing suffocation; but illuminating gas contains in admixture about 5 per cent. of carbon mon-oxide, which is decidedly poisonous. In coal mines the men are warned of the presence of small quantities of gas by the blue halo round the flame of their lamps. Fire damp is ignited by a flame as both its constituent elements, carbon and hydrogen, unite with oxygen: 7 to 8 per cent. in air free from dust becomes explosive, with 10 to 12 per cent. the explosion attains its maximum, with 20 per cent. the mixture no longer explodes, but extinguishes a flame plunged

into it. The combustion of 1 cub. ft. of methane renders about 40 cub· ft. of air unfit for respiration. The ignition of fire damp has been variously determined as 650deg. C. and 780deg. C. As a rule no ignition is produced by a glowing iron or an occasional spark caused by striking a steel tool against some hard substance, but a flame or electric spark, or a series of sparks is necessary. This is said to be due to the fact that the gas requires time to attain ignition temperature, and that with limited heat the gas is first warmed, then ascends before the ignition temperaure is reached.

CHAPTER V.

Queensland.

The total output of Queensland coal for 1909 was 756,577 tons, valued at £270,726, or 7/1¾ per ton. The three chief producing districts are: 1st, Ipswich and Darling Downs, with a yield of 642,864 tons; Wide Bay and Maryborough (Burrum) with an output of 92,573; and the Rockhampton and Central district (Dawson Mackenzie), yielding 21,007 tons.

Some of the Queensland coal measures belong to the Mesozoic area: these include the Styx and Burrum coalfields of the Lower Trias-Jura series, and the Ipswich, Callide and Stanwell coalfields of the Upper Trias-Jura series. The Palæozoic coal measures are comprised in the Upper and Lower Bowen series, the highest members of the Permo-Carboniferous system. The coalfields that belong to the Palæozoic coal measures are those of the Upper Bowen of Clermont (Blair Athol) and Tolmies, and the Lower Bowen of the Dawson and Mackenzie Rivers.

The coal export trade of Queensland is very small and irregular, the imports from New South Wales being greatly in excess.

The Dawson-Mackenzie coalfields belong to the Lower Bowen series. According to B. Dunstan‡ there is an immense area of country on either side of the Central Railway Line, north and south, which contains coal measures of great economic value. Of the 7000 square miles of country which have been examined, there are about 5000 square miles possibly coal-bearing, which by no means represents the limit of the country supposed or known to be coal-bearing, as both to the north and south of the area examined coal has been found in numerous places. To the south the extension of the Dawson coal measures might be continued close to the Western Railway line, and to the north the measures might continue uninterruptedly up the Isaac River to the Bowen River dis-

‡Geology of the Dawson and Mackenzie Rivers, with Special Reference to the Occurrence of Anthracitic Coal. (By Authority, Brisbane, 1901.)

trict. In the area of 5000 square miles of coal bearing country, outcrops of anthracite coal occur in two localities 100 miles apart. The anthracitic character of the coal has been caused by the general contortion of the coal measures. The first coal seam in the Dawson-Mackenzie valley was discovered in 1901, about 40 miles south of the Central line. W. E. Cameron writes*:—"The fact that coals of high steaming character have been found at such widely separated parts (Walker's Creek being some 220 miles from the coal beds of the Dawson), and that the beds are continuous between the two places, give a promising forecast for the great resources of this portion of Queensland in high class steaming coal."

The three chief properties on this field are the Bluff, Mammoth and Dawson River. The Bluff colliery was the first to become an active producer. There are several coal seams in this field. One bore, sunk to a total depth of 520ft. 6in., struck 8ft. of soft coal at 52ft.; 14ft. of coal at 264ft.; 10ft. of coal at 410ft.; 2ft. of coal at 422ft.; and 3ft. of coal at 429ft. At the Mammoth Colliery a seam 24ft. thick has been struck.

The mean of several analysis right across the main coal seam on the Dawson River, which was 10ft. thick, gave:—

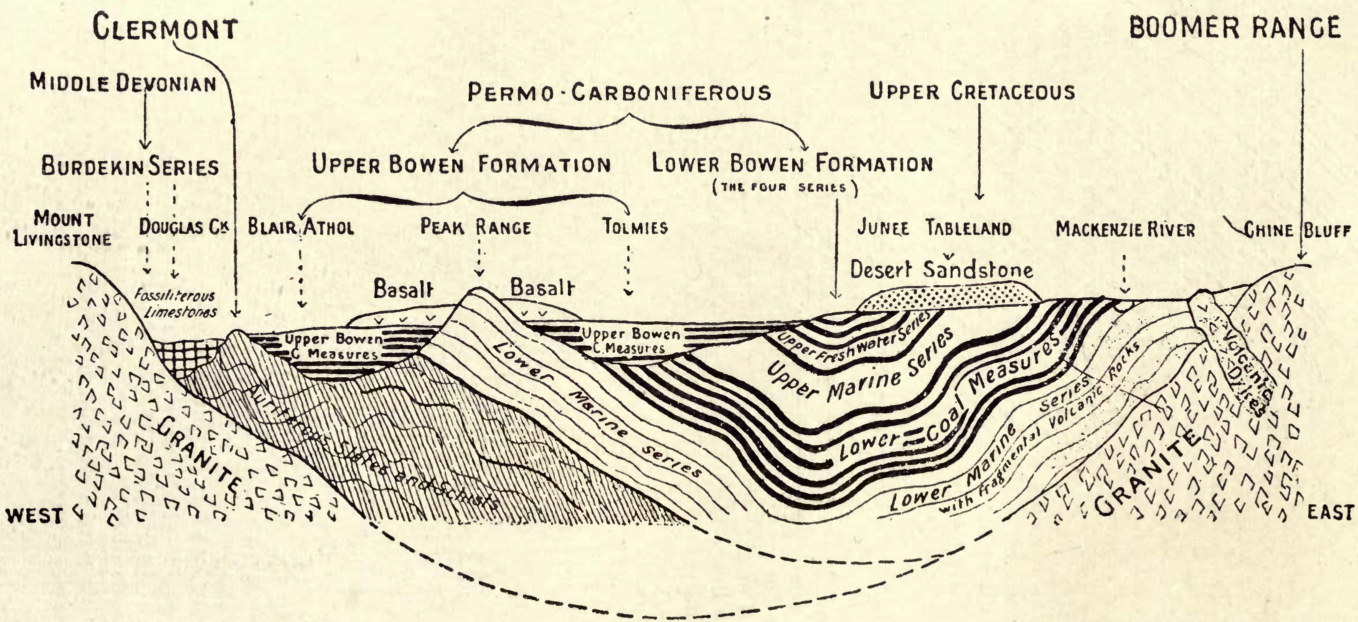
Moisture.	Vol. H. Carb.	Fixed Carb.	Ash.	Sulphur.	Sp. Grv.
3.75	12.98	78.45	4.84	trace.	1.42

Some of the Dawson-Mackenzie anthracite is very friable, and does not carry well. It is rather slow in lighting, but is smokeless, and gives an intense heat. The ash clinkers and clogs the fire bars, making it impossible to keep up a full head of steam, but being brittle it is easily removed. Tests made by C. B. MacDonald, the Coal Inspector for the Queensland Railway Department, showed that 1lb. of this coal evaporated 9.4 and 9.7lb. water at 212deg. Fahr. A trial of this coal on H.M.S. "Wallaroo" required 4.1lb. of coal per square foot of grate surface per hour, and it took 3.2lb. coal to develop 1 I.H.P.

The relation between the coal measures of the Upper and Lower Bowen series is shown in the accompanying section, Fig. 27, by B. Dunstan, taken from his report on the Geology of the Dawson and Mackenzie Rivers.

At Tolmies two coal seams known as the top and bottom seam outcrop at the surface. The top seam being of inferior quality has not been worked, but the bottom seam has been prospected. These seams are of bituminous coal, and belong to the Upper Bowen series. Analysis of the bottom seam by

*The Central Queensland (Dawson-Mackenzie) Coal Measures. (Govt. Survey Rept. No. 200, Brisbane, 1903.)



CLERMONT
BOOMER RANGE
MIDDLE DEVONIAN
PERMO·CARBONIFEROUS
UPPER CRETACEOUS
BURDEKIN SERIES
UPPER BOWEN FORMATION
LOWER BOWEN FORMATION
(THE FOUR SERIES)
MOUNT LIVINGSTONE
DOUGLAS CK
BLAIR ATHOL
PEAK RANGE
TOLMIES
JUNEE TABLELAND
MACKENZIE RIVER
CHINE BLUFF
Desert Sandstone
Basalt
Basalt
Fossiliferous Limestones
Upper Bowen C Measures
Upper Bowen C. Measures
Upper Freshwater Series
Upper Marine Series
Lower Coal Measures
Lower Marine Series
Lower Marine Series with Fragmental Volcanic Rocks
Volcanic Dykes
Auriferous Slates and Schists
GRANITE
GRANITE
WEST
EAST

Fig. 27.

the Government Analyst, the samples being taken between different bands of shale, are as follows:

Moisture.	Vol. H. Carb.	Fixed Carb.	Ash.
7.1	21·1	43.6	28.2
2.2	19.9	53.0	24.9
1.4	24.1	59.1	15.4

Coal was discovered at Blair Athol in the year 1864, while a well was being sunk on the Blair Athol Freehold Block; but for this, it is probable that coal would not have been discovered, as there is absolutely no surface indication to show that coal exists below.

*B. Dunstan says that, taking everything into consideration, it is very probable the Blair Athol coal basin contains at least five square miles as coal land, and that future developments may indicate twice this area, as being possibly coal-bearing· The two coal seams already known to occur are approximately about 1000 feet above sea level, and vary in depth to about 120 feet below the surface. The top seam averages about 4ft. 6in. in thickness; and the bottom seam, 15ft. thick, is about 17ft. lower. These seams do not appear to have suffered much local disturbance, alhough a general elevation must have taken place over the whole district to have brought the coal measures so many feet above sea level.

Analysis of coal from the top (A) seam and bottom (B) seam are given below:—

	Moisture.	Vol. H. Carb.	Fixed Carb.	Ash.	Sulp.
A.	5.6	32.4	57.5	4.5	trace.
B.	5	27	61	7	trace.

This coal does not coke satisfactorily: it also deteriorates very much on exposure to the atmosphere. It has been used for railway purposes for a considerable time: the coal burns very freely and leaves but little ash, which is easily cleaned from the fire bars, but the stokers complain that inferior coal is mixed with the good coal, thus spoiling its value. Locomotive tests required 182lbs. Clermont coal per train ton mile·

Coal seams have been known to exist in the Nebo district for many years. Two prospecting shafts were sunk on coal in the bed of Bee Creek in 1878, but no attempt has been made to develop these coals; their distance from a port—the nearest point of the coalfield being about 60 miles from Mackay—and the difficulties of transport across the coastal ranges, prevents their being brought into market for the present.

So far no coal seams of workable thickness and quality have been found in the Hazeldean and Black Rock Creek beds: it is dirty and has been much disturbed and burnt by contemporaneous flows of basalt and subsequent intrusions of plu-

*The Permo-Carboniferous Coal Measures of Clermont and Associated Formations. (By Authority, Brisbane, 1900).

tonic rocks. The geological age of these seams is a matter of doubt; they are probably equivalents of the Lower Freshwater series of the Lower Bowen Formation, which are Permo-Carboniferous.

The Burrum coal basin belongs to the Lower Trias-Jura. The principal seams are the Bridge seam: about 220ft. lower is the Lapham or Torbanlea (Beaufort?) seam, from about 2ft. thick with 4in. band to 6ft. 2in. with a 1ft. 3in. band; some 35 to 40ft. lower is theBurrum seam, about 3ft. 7in. thick, also with a band of varying thickness: 113ft. lower is the New or Jewel seam, which is 2ft. 6in. of dirty coal; 95ft. below this is the Watson seam, 4ft. thick; 270ft. lower the North Hartley seam, 4ft. 2in.; and about 200ft. deeper, the Blenesk seam, 1ft. 6in. to 2ft. thick. All these seams have not been worked, and some have been worked and abandoned; while others, again, are good in some places but too small or dirty in others. The Torbanlea seam is harder and better coal, especially for gas making purposes, than the Burrum seam. The seams on the northern side of the Burrum River appear to be more disturbed than those on the southern side, and they are subject to several small faults. According to R. L. Jack and R. Etheridge, jun.†: "This coal field extends along the eastern coast line from Point Cartwright on the south at least to Littabella Creek on the north, and stretches inland for an average distance of 25 miles. Its area may be roughly estimated at 3000 square miles."

The following are analysis of coals from the Burrum Coal Field, given by W. H. Rands‡:—

Name of Seam.	Water.	Volatile Hydro-carbon.	Fixed Carbon	Ash.	Sulphur.	Spec. Grav.	Coke.
Queensland Collieries' Co.'s Seam	2.54	30.35	64.30	2.50 (grey)	0.35	1.24	66.80
Lapham or Torbanlea Seam (Torbanlea Colliery) bottom coal	2.0	28.0	61.60	8.00 (grey)	0.40	1.31	69.60
Ditto, top coal	2.25	29.15	66.50	2.10 (grey)	—	1.26	68.60
Burrum Seam (Torbanlea Colliery) ...	2.75	28.00	65.55	3.25 (reddish)	0.45	1.27	68.60

†Geology of Queensland and New Guinea, p. 300 (Brisbane).

‡The Burrum Coal Field (By Authority, Brisbane, 1886.)

The Burrum coal is a coking and gas making coal. Locally it is considered that the coal south of the Burrum River is better suited for coke making than that on the north. At the gas works, the amount of gas obtained in ordinary working is 10,200 cubic feet per ton of coal. The coal being friable is not very suitable for steaming purposes, as it will not stand handling. The iron in the clinker is heavy on the bars, and the clinker sticks to the bars.

The Ipswich Formation consists of conglomerates, sandstones, and shales, with a probable thickness of some 2500ft., in which are 14 or 15 interbedded coal seams, which have been worked at one time or another, estimated to cover an area of about 12,000 square miles in south-eastern Queensland. The Ipswich beds belong to the Upper Trias-Jura, and are known to contain coal seams at many widely separated points over this area, though they have been most extensively worked in the neighbourhood of the town of Ipswich, which is twenty-five miles south of Brisbane, by rail. There are several faults of considerable throw around Ipswich, which generally run in a N.W and S.E. direction, parallel with the axis of folding of the Ipswich beds, with a down throw to the N.E. They have no doubt been formed by the same movement which resulted in the folding of the beds. The faulting and folding renders mining more difficult than it otherwise would be, and also renders any prediction from geological evidence as to their existence in a workable condition, at points even a short distance apart, a matter of great uncertainty. According to W. E. Cameron,* from whose work much of the following information has been obtained, the Ipswich coal may be divided into four areas. (1st) North Ipswich, or Tivoli; (2nd), Blackstone and Bundamba; (3rd), Swanbank and Cooneana; and (4th), Dinmore.

The North Ipswich or Tivoli Coal Area.—Between the basal conglomerates and the lowest worked seam in the North Ipswich area are about 700ft. of carbonaceous and sandy shales, with thin sandstones and conglomerates. They contain several thin seams of coal that have been opened up at various points, but none of which have so far proved of workable thickness. Practically all the workable coal of this area has been obtained between Mahi Creek on the west, to a little east of Sandy Creek, measuring about three miles along the outcrop, and about a mile and a half across. Seven seams outcrop, all of which have been worked for coal. The perpendicular dis-

*Geology of the West Moreton or Ipswich Coal Field. (By Authority. Brisbane, 1899). The West Moreton (Ipswich) Coalfield, Second Report on. (By Authority, Brisbane, 1907).

tance between the lowest—the Benley—and the uppermost—the Garden—seams, is about 900ft. The continuity of the seams is broken by two large parallel faults running in a N.W. and S.E. direction, with down throws to the N.E., known as the Tivoli and Bishop faults.

The Benley seam has 4ft. 3in. of workable coal, with 6in. of stone; the coal is intermixed with a good deal of sandy material. It is overlain by about 10ft. of shale, above which there is another 3ft. of workable coal: below are 5ft. of sandstone and thin coals, under which are another 4ft. of workable coal.

The Bishop, or big seam, is 100 to 150ft. above the Benley seam: it is 11ft. 1in. thick, including two bands of stone; one three inches, the other one inch thick.

The Boxwood seam, formerly thought to be the same as the Bishop seam.

The Tivoli seam is about 120ft. above the Bishop seam: it varies from 6ft. thick, including two bands of stone, 10 and 4 inches thick, to 2ft. 5in., including two bands, one 1in., the other half an inch thick.

The Waterstown, or Cuffe's Lower Seam, is met with about 240ft. above the Tivoli seam. It is 3ft. 7in. thick, including two stone bands of one and two inches thick.

The Fiery, or Cuffe's Upper Seam, so-called on account of its burning with a bright flame, is about 50ft. above the Waterstown seam, and is 3ft. 6in. thick. This, Mr. Cameron considers, is the same as the Bell seam.

The Tantivy seam is about 230ft. above the Fiery seam. The coal is rather dirty, but can be used for household purposes.

The Garden seam is from 100 to 150ft. above the Tantivy seam, and is about 7ft. thick. The coal has a short fracture, breaks up into small cubes, soils the fingers, and is full of bright bituminous streaks.

The Coal Beds of Blackstone and Bundamba.—Coal seams have been exposed over an area of about 12 square miles, lying mainly to the south of the Brisbane to Ipswich railway line, between Six Mile and Bundamba Creeks, and from there to eight miles east of Ipswich. At least seven well recognised beds of coal have been found, of which six have been worked at one time or another.

The Ipswich, or West Moreton coalfield, is at present the chief producing coalfield of Queensland; it turns out more than 75 per cent. of the total coal production of that State. Owing to the increased demand for this coal a few years ago, a number of new collieries started, especially along the southern extension of the outcrop of the Aberdare seam. The demand, however, was not equal to the possible output, with the result that there was a glut on the market, prices went down, and

most of the pits were periodically idle. The Bundamba district supplies over three-fourths of the coal turned out from the West Moreton coalfield. The Aberdare seam furnishes nearly 58 per cent. of the total production of the field, two-thirds of its total coming from the four mines about Box Flat. Another 21½ per cent. is derived from the New Chum seam; so these two seams provide the bulk of the coal from the district. The cost of mining might be considerably decreased were the areas held by one company greater, thus reducing the aggregate cost of management, and laying out of the mines.

The West Moreton seam is 2ft. 3in. thick. Three hundred and forty-five feet below this is the Aberdare seam, 13ft. 10in. thick, including three stone bands 5in., 12in. and 6in. thick respectively; in addition there are smaller bands, leaving about 11ft. of coal. As the seam is followed to the south, the lower section of four feet of coal becomes thinner and of poorer quality, while in the Aberdare mine, to the north, this section was worked 5ft. in height, over a large area. The seam is worked in two sections. In some cases the top 68in. are taken down first, the bands of stone being picked out before filling. The foot band in the floor is then left as a roof above the lower rooms. In the other case, where the bottom coal, below a mixture of coal and stone known as "The Badger," is poor, the top section is worked as before; then the band of stone is stripped by yardage, after which the underlying coal, above "the badger" is lifted, that below "the badger" being left. This seam furnishes the best steam coal in the district. The Aberdare colliery was the first to open out on this seam, and still takes the lead in output of any colliery in the State. Other collieries working this seam are West Moreton, Borehole, Fairbank, Box Flat, Bog Side, Mafeking, Bonnie Dundee, New West Moreton, and Fernie Creek. The Box Flat colliery was the first to instal a coal-cutting machine on this field.

The Bluff, or Dirty seam, is from 116ft. to 185ft. below the Aberdare, and consists of 30ft. of alternate stone and coal bands. The thickest band of coal is only about 2ft., and that is of inferior quality. So far, this seam has not afforded a workable section of coal in any portion of the field.

Stafford's Four-foot-six seam is 296ft. below the Bluff. It is easily recognised over the greater portion of the district from the fact that it lies immediately under the first thick bed of sandstone under the Aberdare seam. It generally shows about four feet of clean coal at the bottom, above which are two thin bands of stone, and two bands of coal, about 7 and 15in. respectively. This seam was originally worked by the old Rosehill, Borehole, and Braeside collieries, in workings long since abandoned.

Other seams below Stafford's Four-foot-six are known as Bergin's, Striped Bacon, Rob Roy, and Doby's seams. They have all been worked to some extent along the western fall of the bed between Bundamba and Blackstone, but the workings have been abandoned for some years. Lately two new collieries have been opened up on coals occurring in these beds on their eastern fall towards Six-mile Creek.

At Bundamba four seams, each from 3 to 4 feet of good coal, have been met with, known as Braeside No. 1, Braeside No. 2, Braeside No. 3, and Braeside No. 4, or hard coal: they are 75, 40, and 140ft. apart respectively. Braeside No. 1 is supposed to be identical with Bergin's seam, in which case the lower ones are, no doubt, the Striped Bacon, Rob Roy, and Doby's seams.

The Coal Beds at Swanbank and Cooneana.—Here there are two seams, Swanbank No. 1, and Swanbank No. 2. The former is considered by Mr. W. E. Cameron, in his second report on this field, to be a continuation of the Four-foot-six seam. It has been worked to a small extent in the Swanbank Colliery. The latter he looks upon as corresponding to the position of Bergin's seam about Blackstone. This seam has been worked in the Swanbank and Denham collieries. At Perkins' Freehold there is a seam 5ft. thick, including bands which are no doubt the same as the Striped Bacon and Rhondda seams.

Coal Seams in the Neighbourhood of Dinmore.—This area is bounded by Stafford's Tunnel fault on the S.W., and the Ebbw Vale fault on the N.E. There are three seams, New Chum No. 1, New Chum No. 2, and New Chum No. 3. The bottom coal of the New Chum No.1 seam is generally known as the New Chum seam, and is the only one that has been extensively worked in this district. It has been worked from a number of vertical shafts in the Whitwood, Dinmore, New Chum and Ebbw Vale mines. The New Chum No. 1 seam is probably identical with the Striped Bacon and Rhondda seams. The section worked shows from 3ft. 8in. to 5ft. of clean coal, separated by two bands of white stone with coal between. Numerous faults have dislocated the seam, some of them having over 100ft. displacement, which prove a very serious obstacle to the economical working of the coal.

The New Chum No. 2 seam, with about 5 feet of coal, has been found by boring 74ft. below the New Chum bottom coal. Apparently this has no representative on the Bundamba side.

The New Chum No. 3 seam is 68ft. below the New Chum No. 2, and corresponds with the Braeside hard coal.

The old Aberdare seam is also found in this area, about 200ft. above the New Chum seam.

The correlation of seams found in the different districts has been no easy matter, owing to earth movements, and changes in the strata and seams themselves.

Recently a commencement has been made to mine coal at Mundah, a few miles from Brisbane. The seam is about 4ft. 6in. thick, of which about 3ft. is good coal, mixed with two bands.

The following analyses were made at the Government Analyst's office of samples from exhibits at the Queensland International Exhibition of 1897:—

Locality	Moisture	Volatile Hydro-carbon.	Fixed Carbon	Ash	Sulphur
South of Bremer River, Moreton District ..	1.65	30.52	60.52	7.20	1.101
North of Bremer River, Moreton District ..	1.25	25.78	63.59	9.38	1.26

The coals from north of the Bremer River contain a higher proportion of fixed carbon and ash than those from south of the river. They cake well, giving an excellent coke, but are not, as a rule, so suitable for steam purposes. The coals from south of the river have more volatile hydrocarbons, do not cake well enough to give good coke, but are more suitable for steaming purposes. The Ipswich coals are friable, and do not bear carriage well; they also suffer from exposure to wet, so that the harder varieties, though containing more ash, are found in practice to be more economical, in consequence of the smaller proportion of waste: but R. Wilson, who made several tests with this coal, states that its friability does not seem to interfere much with its steaming qualities. The tests carried out on the Government s.s. "Otter" gave the following information:—

	Amount of water evaporated per lb. of coal consumed from and at 212 deg. F.	Calorific value of each lb. of coal as burned.	Coal consumed per I.H P. per hour.
Aberdare seam (Blackstone) ..	8.027	7,759.292	2.375
New Chum seam (Dinmore) ..	7.683	7,426.842	2.45
Waterstown seam (Ipswich) ..	7.0226	6,788.04	2.54
Bishop seam (Ipswich)..	7.54	7,294.776	2.575
Burrum Coal Field	8.146	7,874.193	2.171

According to A. C. Gregory* "The general character of the coals found between Walloon and Warwick is that of cannel coal. It does not cake in coking, gives a high percentage of gas, or oil and paraffin, according to its treatment

*Report on the Coal Deposits of the West Moreton and Darling Downs District, Brisbane: by Authority, 1876.

at a high or low temperature. Its hardness renders it very suitable for export. It burns very freely, and leaves a soft, white ash. From the small proportion of fixed carbon, and its not caking, it does not produce good coke, but a charred coal, which, however, burns well; consequently it is not well adapted for blast furnaces, though well suited for reverberatory furnaces. As a steam coal it is best suited for stationary or marine engines, the strong blast of locomotives being apt to blow it through the tubes. It is a very high-class household coal."

An analysis of coal from Walloon shown at the Queensland International Exhibition of 1897 gave:—

Moisture	Volatile Hydrocarbon	Fixed Carbon	Ash	Sulphur
4.70	38.08	47.94	9.28	1.50

The Stanwell coal field is a few miles S.S.W. from Rockhampton; the town of Stanwell has a railway station on the Central Queensland railway. D. Dunstan† says that "The coal measures here occupy an area of about seventy square miles, of which fifty would be quite useless for prospecting purposes, the remainder being possibly coal bearing. The most important part of the measure is contained between Stanwell and Bushley, but from this, the main area, branches spread out in all directions." Coal was first discovered here unexpectedly by Mr. Petersen, while sinking a well in the bed of Quarry Creek, on his selection. The coal found occurred in thin seams, and was not too clean, so that there has been no encouragement to start mining on this field.

A hydrous or brown coal is found at Valentine Creek and Waterpark Creek. W. E. Cameron‡ says that up to the present there is no evidence either stratigraphical or palæontological, to allow of the age of these beds being determined. On the map accompanying the report they are put down provisionally as Trias-Jura. The coal is dull brownish-black, compact and finely laminated in structure, and breaks up on exposure to the air into irregular lumps, with a subconchoidal fracture. It ignites with difficulty, and burns with a smoky flame, giving off a tarry odour. There are 63ft. of coal, with bands of sediment and black carbonaceous mud, alternating with each other. Fully five-sixths of the strata passed through was coal, some of which was much harder than others, notably two feet.

†The Mesozoic Coal Measures of Stanwell, and Associated Formations (By Authority, Brisbane, 1898).

‡The Coal Beds on Waterpark Creek, near Port Clinton (By Authority, Brisbane, 1902).

14ft. down; and five feet, 28ft. down. Analysis of Waterpark Creek coal gave:—

	From shaft on Valentine Creek.		From outcrop on Waterpark Creek.	
Moisture	10.25		10.72	
Volatile hydrocarbon (total combustibles)	41.38	80.16	40.76	83.63
Fixed carbon	38.78		42.87	
Ash	9.59		5.65	
Sulphur	1.16		1.20	

This coal has not been put to any use as yet.

CHAPTER VI.

New South Wales.

Coal was first discovered in New South Wales in August, 1797, at Coalcliff, north of Wollongong, and about a month later it was discovered in the cliffs at Newcastle.

The total output and value of coal from the New South Wales coalfields from the inception of coal mining to the end of 1909 was 154,845,053 tons, worth £59,250,850. The largest output was in 1908, when the tonnage amounted to 9,147,025. The total output and value of coke from 1890 to 1909 was 2,223,900 tons, worth £1,602,807.

The total output and value of kerosene shale from 1865 to 1909 was 1,422,019 tons, worth £2,217,185.

The coal bearing rocks of New South Wales are classified as follows:—*

Geological Age.	Maximum Thickness.	Character of Coal.
1. Tertiary, Eocene to Pliocene..............................	About 100ft	Brown coal or lignite.
2. Mesozoic, Triassic.........	2,500ft.	Coal suitable for local use only.
3. Palæozoic— (a) Permo-carboniferous...	13,000ft.	Good coal, suitable for gas making and for household and steam raising purposes.
(b) Carboniferous.................	10,000.	Very inferior coal, with bands of no value.

1. The Tertiary deposits of brown coal and lignite are of limited extent in New South Wales, and occur mostly in the deep alluvial leads. They have not been put to any commercial use.

2. The Triassic coal measures are seen in the Clarence River basin, which extends about 120 miles north and south, while its greatest width is about 65 miles from east to west. At least five coal seams have been discovered in the Lower Clarence measures, varying in thickness from 2 to 37 feet,

*E. F. Pittman, "The Mineral Resources of New South Wales." Published by authority: Sydney, 1901.

but in every case they are largely made up of bands, and it is a rare thing to find a layer of clean coal of more than one foot in thickness between the bands. The percentage of ash is too great to allow the fuel to be exported. But though of little value in New South Wales, this coal basin extends to Queensland, where, at Ipswich, thick and valuable seams are worked on an extensive scale. It is not known for certain whether the Ipswich measures are equivalent to the Upper or Lower Clarence series, though it is probable they are the latter.

3. Permo-Carboniferous Deposits.—These are the most important productive coal seams of New South Wales. They cover an estimated area of 24,000 to 28,000 square miles. Prof. T. W. E. David classifies these deposits as follows in descending order:—†

	Thickness.
Upper or Newcastle coal measures	1200
Dempsey series	2000
Middle, Tomago or East Maitland coal measures ..	700
Upper Marine series	5000
Lower or Greta coal-measures	130
Lower Marine series	4800

The upper coal-measures are well developed in the neighbourhood of Newcastle, in the northern coal field; Bulli, in the southern or Illawarra coal field; and near Lithgow, in the western coal field.

The following are the principal seams in the Upper coal-measures near Newcastle in descending order:—

The Wallarah or Bulli seam	about 11ft. thick
The Great Northern seam	about 20ft. thick
The Fassifern seam	about 24ft. thick
The Upper Pilot seam	about 7ft. thick
The Lower Pilot seam	about 10ft. thick
The Australasian or Cardiff seam	about 5ft. thick
The Yard seam	about 3ft. thick
The Burwood or Victoria tunnel seam from	6ft. to 8ft. thick
The Nobbys seam .. .. from	5ft. to 6ft. thick
The Dirty seam—splits into two in places .. .. from	6ft. to 10ft. thick
The Young Wallsend seam	about 10ft. thick
The Borehole seam .. .. from 4ft. to 23ft.,	usually 8 to 9ft.
The Upper Sandgate seam	about 6½ft. thick
The Lower Sandgate seam	about 11½ft. thick

†"Discovery of Glaciated Boulder at Base of Permo-Carboniferous System, Lochinvar, N.S.W. Jour. Roy. Soc., N.S.W., Vol. xxxiii. (1899), p. 154.

In the Illawarra coal field the following seams occur in descending order:—

The Bulli seam .. .. from 2 to 11ft. thick, usually 6 to 7ft.
The Four feet .. .. about 4ft. thick
The Thick .. .. about 14ft. (several small seams)
The Eight feet .. .. from 7 to 9ft. thick
The Bottom .. about 6ft. thick, including numerous bands

The Bulli seam is the only one that has been worked to any consideable extent in the southern coalfield, the lower seams, so far as prospected, being found to be slightly inferior. It is the Bulli seam that was struck in the Cremorne bore near Sydney.

The kerosene shale that occurs at Joadga Creek, Hartley Vale, Katoomba, Capertee, etc., belong to the Upper coal-measures.

The coal from the different districts varies considerably in composition. That from Newcastle is most suitable for gas making and household purposes, and contains the least amount of ash. The coal from the southern and western fields is essentially a steam coal. Some of the Southern coal makes good coke, though it is rather high in ash, as the coal does not lend itself to washing, the impurities being so finely disseminated through it. Some of the western coal from Lithgow also makes good coke after being washed.

The Dempsey series does not contain any productive coal.

The Middle or Tomago coal measures outcrop in the neighbourhood of East Maitland and dip under the Dempsey series and Upper coal-measures. The following are the principal seams in descending order:—

The Top or Donaldson's seam .. .. .. from 4ft. to 6ft. thick
No. 2, Big Ben, or Tomago thick seam from 7ft. to 10ft. thick
No. 3 seam .. .. about 6ft. thick
No. 4 seam .. .. about 3ft. thick
No. 5 or Tomago thin seam .. .. about 2½ft. thick
Scotch Derry seam, probably an upper split of the
Rathluba seam .. about 9ft. to 10½ft. thick, containing numerous bands.
The Rathluba seam .. from 4ft. to 11ft, usually about 5ft.
The Ironstone seam .. .. about 2ft. thick
The Morpeth seam .. from 4 to 8ft. thick, with bands.
A rather dirty seam, scarcely workable.

Out of a total thickness of about 40ft. of coal in the Middle coal-measures, about 20ft. have proved workable. It is for the most part friable, and suitable rather for local use than for export.

The Lower or Greta coal measures occur between West Maitland and Greta. There are two seams worked in these measures, viz.:—

The Upper seam, varying between 14 and 32ft. thick.
The Lower seam, varying between 3 and 11ft. thick.

The average aggregate thickness of coal in these measures has been estimated at about 20ft. The Greta seams are sometimes inclined at a considerable angle, as at East Greta, where the dip is 45 degrees.

The Lower coal-measures have been recognised in the extreme southern portion of the Illawarra coal-field; but so far as prospected the seams do not appear to be workable under present conditions.

The Ashford coal-field is a long narrow field, about a quarter of a mile wide, north of Inverell, which appears to belong to the Greta coal measures. It contains a 27ft. thick seam, which dips at a high angle, and is much disturbed. The quality of the coal appears to be good, but owing to the field being in a somewhat remote part of the State, and not connected with a railway, it remains unworked.

The Carboniferous coal measures occur in the neighbourhood of Stroud; the coal is, however, very inferior and of no value.

The total contents of the New South Wales coal-fields of Palæozoic age has been variously estimated by different authorities. The late Government Geologist, C. S. Wilkinson, gives it as 78,000,000,000 tons of exploitable coal, in seams not less than 2½ft. thick, within a depth of 4000ft., a deduction of one-fifth being made for waste in the getting, etc. According to Prof. T. W. E. David,* in the gross quantity of coal, in seams not less than 3ft. thick, and within a depth not greater than 4000ft., there are between 130,000,000,000 and 150,000,000,000 tons. Mr. E. F. Pittman,† the present Government Geologist, reckons there are at least 115,000,000,000 tons of available coal, after deducting one-third of the gross quantity of the coal for waste in getting, etc.

Professor David, who has made a special study of the New South Wales coal-fields, considers‡ that as the coal in the Cremorne bore, near Sydney, dips west at the rate of 110ft. per mile, while the seams in the Blue Mountains dip east at the rate of about 90ft. per mile (Fig. 28) the centre of the

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*Australasian Association for the Advancement of Science, 1890, Vol. II., p. 461.

†Mineral Resources of New South Wales, p. 322.

‡Summary of our Present Knowledge of the Structure and Origin of the Blue Mountains of New South Wales, Jour. Roy. Soc. of N.S.W. (1896), xxx., 33.

basin is probably in the neighbourhood of Parramatta. The Permo-carboniferous system of rocks is separated from the Devonian by a strongly marked unconformity. After the folding of the Carboniferous and Upper Devonian formations, a great land building epoch in the history of the Australian continent caused ranges to become established west of the present site of the Blue Mountains; sediments derived from the wearing down of the former then began to be deposited in the shallow seas, extending from near Penrith to the continental shelf. These constituted the strata of the Lower Marine Series (Permo-carboniferous), Prof. David continues, "Swampy or lacustrian conditions succeeded, and the Greta coal-measures were laid down over an area about two hundred miles long, from north to south, and from thirty to forty miles from east to west. A considerable subsidence ensued, during which the waters of the Pacific penetrated to at least as far inland as Mount Lambie, about seventy-two miles inland from the present coast. The subsidence amounted to a maximum of about five thousand feet in the Maitland district, and two thousand five hundred feet in the Illawarra district. The strata of this epoch belongs to the Upper Marine Series. The cessation of the subsidence was accompanied by volcanic eruptions, most extensively developed in the Kiama neighbourhood, but represented also on a smaller scale by the volcanic rocks near Rylston. Swampy conditions returned on a larger scale than ever, and the Bulli-Newcastle coal measures were formed in the Blue Mountains area, while in the Newcastle area, a middle group of coal measures (The Tomago Series) was developed as well, being interstratified between the top of the Upper Marine Series and the best of the Dempsey beds, which underlie the Newcastle coal-measures. The abundance of fossil trees referable to *Arau carioxylon*,† many preserved in the form of stumps in situ in the formation in which they grew, is clear proof that the conditions under which the Newcastle-Bulli coal measures grew were terrestrial rather than marine. The formation of the last of the coal seams of the Newcastle-Bulli series closes the history of the Palæozoic era in New South Wales."

For full details of the geology of the Northern coal-field, the reader is referred to the excellent monograph by Prof. T. W. E. David on "The Geology of the Hunter River Coal Measures, New South Wales," recently published by the Department of Mines and Agriculture.

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†Since transferred by Mr. E. A. N. Arber, of Cambridge University, to the genus *Dadoxylon.*

CHAPTER VII.

VICTORIA.

In Victoria bituminous coal occurs in the Mesozoic rocks, while brown coal and lignite of the Tertiary era are found in large quantities. So far no workable coal seams have been found west of Port Phillip, notwithstanding several deep bore-

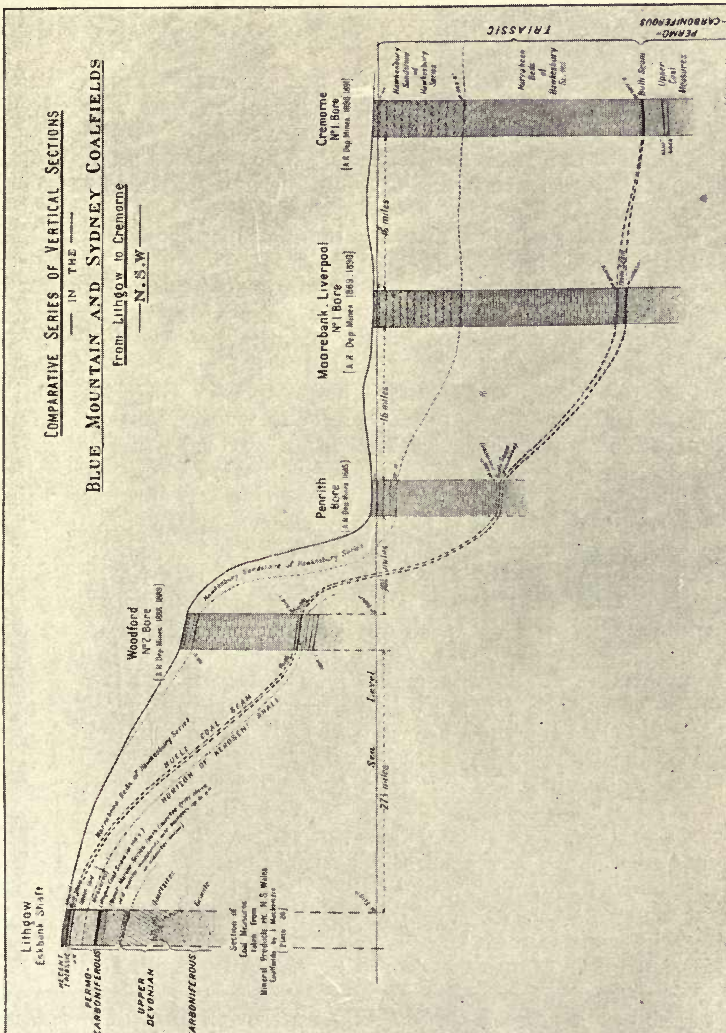

Fig. 28.

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holes that have been put down in the Mesozoic areas there. Coal mining has been confined to South Gippsland, the total output from which to the end of 1909 amounted to 3,054,987 tons, valued at £1,689,755. The output of coal for 1909 was 128,173 tons, valued at the pit's mouth at £76,870, or 12/- per ton. The principal mines, arranged in order of their production, are the Jumbunna Coal Mine, Outtrim, Howitt and British, Austral Coal, State Coal Mine, and Coal Creek Proprietary.

The Victorian coal measures are generally much faulted and subject to many variations of direction and rate of dip. The coal seams are small, with the exception of the Mirboo seam, which is about 56in. thick. The quality of Victorian coal is not equal to that of the average New South Wales coal; it also breaks up more readily, causing greater loss in carriage. The Victorian railways are the principal consumers of local coal.

Victoria is rich in Tertiary brown coals and lignites. Jas. Stirling* states that at one locality, Maryvale, near Morwell, a diamond drill bore, carried to a depth of 1010ft., passed through seven beds of brown coal, three of which were 265ft. 6in., 227ft. 10in., and 166ft. 1in. respectively. Two miles south of Darnum 33ft. of brown coal was cut in a shaft at 60ft. from the surface. At Yarragon, several seams were cut from 1ft. to 67ft. At Langridge Gully there is a seam 15ft. thick; while at Narracan Creek Valley there is one 20ft. thick. The Ferngrove seam is 40ft. thick. Between Moe and Morwell there are seams 20, 53, 97 and 200 feet thick. At Hazelwood there are seams 7, 10, 21 and 37 feet thick; while at Boolara there is one 162ft. thick. Other deposits of brown coal, or lignite, are known at Darlimurla, Tyers River, Toongabbie, Thomson and Avon River Valleys, Calignee, Carrajung, Won Wron, Mount Look-out near Bairnsdale, Bass River Valley near Westernport, Port Phillip Bay (Mornington, Newport, Altona Bay), Werribee River, Lal Lal, up to 82ft. thick, and Dean's Marsh.

The following are analyses of some of these coals:—

Locality.	Water.	Volatile Matter.	Fixed Carbon.	Ash.
Yerragon	40.35	20.85	26.60	12.20
Ferngrove	24.54	35.11	34.55	5.80
Great Morwell Co.	28.00	30.17	36.95	4.87
Maryvale, near Morwell, average of 32 samples	22.08	34.66	40.18	2.79

*Report on the Brown Coals and Lignites of Victoria. (Geol. Survey of Victoria. Progress Report, No. X., p. 73 [1899].)

Locality.	Water.	Volatile matter.	Fixed carbon.	Ash.
Mirboo, at Boolara ..	42.34	57.21	27.90	2.55
Lal Lal	22 to 30	15 to 30	40 to 48	18 to 23
Dean's Marsh	21.92	27.14	36.58	14.36

The destructive distillation of tar from the Great Morwell Company's coal gave:—

Water and ammonia	23.6
Light oils	3.6
Carbolic oil	14.0
Creosote oil	6.0
Anthracene	10.7
Pitch and coke	42.0

CHAPTER VIII.

SOUTH AUSTRALIA.

South Australia can hardly be classed as a coal producing country. The only coal find on which there has been any attempt at mining, namely Leigh's Creek, 373¼ miles from Adelaide, on the Great Northern railway line, is at present idle. The coal measures are of Mesozoic age, being the equivalent of the Ipswich coal measures of Queensland, which are Trias-Jura. H. Y. L. Brown* writes: "The secondary rocks which contain the coal bearing shales of Leigh's Creek appear to occupy deep basins, which have been eroded in the softer parts of the older rocks, and which at one time formed a chain of lakes of various sizes and irregular shapes, extending northwards towards the region of Lake Eyre." . . . . "The fossils are of a character indicating vegetable and animal life of a kind which could have existed only in fresh water." The coal in its percentage of water resembles a brown coal, but in other qualities it is more like a bituminous coal; it may be looked upon as intermediate between the two. It breaks up very readily on exposure to the weather. Tests made with this coal, both alone and mixed with Newcastle (N.S.W.) coal, in the Government railway locomotives, proved it to be unsuitable for that class of work; but it was considered a useful coal for domestic requirements, as it gave little smoke and burnt out thoroughly. No. 1 bore, put down on the edge of the basin, at 125ft. struck a 25ft. seam of coal; at 150ft. was one foot of shale, and this was followed by brown coal, shale and coal to 170ft., when blue clay-slate of Palæozoic age was met with. No. 2 bore was sunk one and a half miles from No. 1 bore, near the centre of the basin; at a depth of 1496ft. 8in. a coal seam 47ft. 10in. was found; below this, thin coal seams up to two and three feet were met with, and at 1900ft. they bottomed on primary rock.

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*Reports on the Coal-bearing Area in the Neighbourhood of Leigh's Creek, South Australia, 1891. By authority, Adelaide.

The mean of several analyses taken at different depths of the main seam struck in No. 2 bore is:—

Water at 212deg. F.	Vol. Hydrocarbons.	Fixed Carbon.	Ash
17.45	26.99	41.48	14.12

At Kuntha Hill, 110 miles north of Hergott, three seams have been proved, 2ft. 6in., 2ft., and 5in. thick. Analysis of this coal gave:—

Water.	Volatile matter.	Fixed Carbon.	Ash.
11.68	36.63	42.70	8.99

At Pidinga there is a 30ft. seam of lignite, but the quality is not good enough for use as fuel.

CHAPTER IX.

WESTERN AUSTRALIA.

In this State coal is found of three different periods.

1. The Irwin River basin belongs to the Carboniferous period. The Carboniferous rocks occupy an area of about 200 square miles, but so far no workable coal seam has been discovered; however, the bottom of the series has not been reached by bore holes. The mean proximate analysis of six samples of Irwin River coal gave:—

Moisture.	Volatile Hydrocarbons.	Fixed Carbon.	Sulphur.
19.59	22.64	57.76	0.19

2. The Collie Coal-field.—The age of this coal has not been definitely decided. The balance of palæontological evidence is in favour of it belonging to the Carboniferous period, but from the general physical aspect of the field it will probably prove to belong to the Mesozoic era. Dr. R. L. Jack† is inclined to believe they will turn out to be of Cretaceous age, newer than the coal-fields of Ipswich and Burrum, in Queensland. "The entire absence of igneous dykes penetrating the coal-field argues the probability that it was deposited after the cessation of volcanic activity, and therefore at a somewhat late epoch." All the coal produced in Western Australia comes from the Collie coal-field.

3. Lignites and brown coal of Tertiary and Post-tertiary eras are found at Coolgardie and on the south coast. These are of very poor quality.

The total output of coal from Western Australia—that is from the Collie coalfield—to the end of 1909 amounted to 1,377,452 tons, valued at £708,725. The output for the year ending 1909 was 214,302 tons, valued at £90,965. The Collie coal-field lies south of Perth and east of Bunbury; the coal-measures rest directly on granites, schists and other crystalline rocks. The coal-field is mostly bounded by faults, but the measures themselves are very little disturbed, so far as known, but for the "Wallsend fault," which has an estimated throw of 270 feet.

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†Report of the Royal Commission on the Collie Coal-field Perth, W.A., 1905, p. 7.

According to a generalised section compiled by Dr. Jack the coal measures are 2012ft. 5in. thick, and include 24 coal seams. The chief of these are, commencing at the bottom:—

Wallsend coal	9ft. to 17ft.
Proprietary No. 2 coal	5ft. to 7ft. 6in.
Proprietary No. 1 coal	4ft. to 8ft.
Collie Burn No. 2 coal	6ft. to 7ft. 10in.
Collie Burn No. 1 coal	9ft.
Cardiff No. 2 or Boulder coal	7ft.
Cardiff No. 1 coal	9ft. to 12ft.

Only the very thick seams are worked, and only a portion of these, owing to the uncertain nature of the roof, which, when it falls, sometimes lets in water and running sand, so the top of the seam is generally left as a roof.

A rough estimate given by Dr. Jack of the total amount of coal available in the field is as follows:—

	Tons.
Cardiff No. 1 seam	18,175,104
Cardiff No. 2 or Collie-Boulder seam	17,547,840
Collie Burn No. 1 seam	46,433,088
Collie Burn No. 2 seam	38,966,640
Eight foot seam	50,683,968
Wallsend seam	138,843,936
	310,680,576

This is making a deduction for the top coal that has to be left, also for the large proportion of coal required as pillars, which, on account of the general tender character of the coal, sometimes amounts to nearly 60 per cent. The coal of this field is a hydrous semi-bituminous non-coking coal, and is inferior to the Newcastle coals of New South Wales. Were it not that the Western Australian railways undertook to consume a large proportion of the output, the probability is that the seams would not have been worked. The coal is fragile, partly owing to numerous partings of mother-of-coal in it, and partly owing to spontaneous decrepitation accompanying a loss of moisture on exposure to the air. An idea of the nature of this coal will be given by the following proximate analysis:—

	Moisture.	Vol. Hydro-carbon.	Fixed Carbon.	Ash.	Sulphur.
Cardiff No. 1	15.81	27.07	51.19	5.44	0.49
Cardiff No. 2 or Boulder	18.2	28.2	46.6	6.4	—
Collie Burn No. 1	15.72	30.0	49.51	4.17	0.60
Collie Burn No. 2	14.0	23.9	59.5	2.6	—
Wallsend (Proprietary)	14.36	27.03	51.64	6.66	0.31

The spc. grav. is about 1.3.

The heating value of Collie coal is only about one and a half times that of wood growing in the neighbourhood. The efficiency of Collie coal in stationary boilers is found to be from 8.4 to 10 per cent. lower than that of Newcastle. On locomotives, 100 tons of Newcastle coal was found to be equal to from 142.5 to 170.5 tons of Collie coal.

CHAPTER X.

Tasmania.

Both Permo-carboniferous and Mesozoic coals are found and worked in Tasmania. From 1880 to 1909, inclusive, 1,119,387 tons of coal were produced in Tasmania, valued at £958,309. In 1909 the production was 66,161¾ tons, valued at £56,237. This is the largest output of coal from Tasmania in any one year.

The different seams of coal worked produce coal of various qualities, from semi-anthracite downwards; but, on the whole, they are not of the highest quality, as will be seen from the analysis given. The Permo-carboniferous coal is a sulphurous gas, house and steam coal. The following coal basins are recognised:—

1. The Mersey coal basin. Seams 18 to 20in. thick are worked at Spreyton and Dulverton on a small scale.

2. Preolenna basin, on the north-west coast. Here three seams of kerosene shale are met with; the top one, 20in. thick, is the most important. There is also gas coal in seams up to 3½ft. thick, but it is not worked.

3. Mount Cygnet basin. The Mt. Cygnet seam is 3ft. 6in. to 3ft. 9in. The coal is dull, compact, high in ash, burns slowly, and without much flame, but gives a strong heat in the grate. This seam is looked upon as being younger than the Mersey measures.

4. Southport coal basin. A diamond drill bore was put down for the Southport Coal Prospecting Association to a depth of 612ft. 2in. in 1893. The rocks are regarded as Permo-carboniferous. Nothing of importance was found.

5. Mount Pelion and Barn Bluff Basin. The coal in this basin is not worked. One seam, 17in. thick, of bright firm black coal contains a considerable quantity of pyrites. A second seam is split by a four-inch carbonaceous shale, the upper portion being five inches and the lower 21 inches thick.

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2. G. A. Waller. Report on the Recent Discovery of Cannel Coal in the Parish of Preolenna, and upon the New Victory Copper Mine, near Arthur River, 1901. By authority.

3. W. H. Twelvetrees. Report on Gold and Coal at Port Cygnet, 1902. By authority.

6. The Henty basin, on the west coast. Here there are some insignificant seams, too small to work.

The Mesozoic coal is generally referred to the Trias-Jura. The coal is used for steam and domestic purposes.

1. Fingal coal basin. The two largest collieries in Tasmania are in this basin, viz., the Cornwall, with an output during 1909 of 29,885 tons, and the Mt. Nicholas Colliery, with an output of 27,341 tons. The Mt. Nicholas seams are four to nine feet thick. The Jubilee seam, 7ft. thick, on Mt. Nicholas, is not being worked now; the above thickness includes about 18in. of partings.

2. Ben Lomond. Two seams are found at Mt. Rex, one 6ft. to 7ft. thick, the other 12ft. thick, including five bands aggregating 9½in. This field is not worked.

3. Thompson's Marshes coal basin. This is really a continuation of the Fingal basin from the north, and the Douglas River basin from the south. Three seams have been discovered at Thorndale, but are not being worked. The lowest seam measures 2ft. 3in. to 2ft. 7in. thick, and contains a half-inch parting. The coal is black and dense, with a dull lustre, and is free from pyrites. The intermediate seam is a twin, the upper portion being separated from the lower by a band of clay 4ft. 5in. thick; the top coal measures 5ft. 7in., and the lower 4ft. 9in.; the ash is high, and the coal shows efflorescence of sulphate of iron. The upper seam measures, as far as exposed, 4ft. 2in.; it is not such good coal as the other two seams.

4. Douglas River and Llandaff basin. The seams are found from 2 to 10ft. thick, of fair Tasmanian quality; but they are not being worked, mainly owing to the want of facilities for fetching the coal to the coast, where there is a suitable harbour in Cole's Bay, the water being 6 to 14 fathoms deep. This coal-field is about 11 miles long by two miles wide.

5. York Plains basin. A semi-anthracitic coal is being worked here from a four-foot seam.

6. Colebrook basin, formerly known as Jerusalem. The mines are now idle.

7. Sandfly basin. The seams are four and five feet thick; some of the coal is semi-anthracitic. This is an important

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2. W. H. Twelvetrees, on Coal at Mount Rex, 1905. By authority.

3. W. H. Twelvetrees, Report on Coal Seams at Thorndale, near Thompson's Marshes, and the Jubilee Colliery, near St. Mary's, 1901. By authority.

4. W. H. Twelvetrees, Report on the Coal-field of Llandaff, the Denison, and Douglas Rivers, 1901. By authority.

7. W. H. Twelvetrees, Report on the Sandfly Coal Mines, 1903. By authority.

field, and the Sandfly Colliery, which is just beginning to put out coal, promises to become one of the most important coal mines of Tasmania.

8. Oatlands basin. At Mike Howe's Marsh there is a seam of impure coal 3ft. 6in. to 4ft. thick, which is not worked.

9. Ida Bay and Hastings fields. The coal here is soft and earthy; it is not worked.

10. Recherche basin. At Moss Glen the seams are 6 to 7ft. thick, interspersed with bands.

At Catamaran are two seams, one from 4ft. to 6ft., the other 7ft. thick. The upper seam is being worked.

11. Whale's Head and South Cape Coal-field. Here Mesozoic seams are exposed on the sea coast, but are not worked.

12. Spring Bay Basin, on the East Coast, is of limited area, and not worked.

Other coal basins of the upper measures in sundry parts of Tasmania not worked are the following:—

Tasman Peninsula; Longford; Old Beach, and New Town, both of the Derwent basin; Hamilton, and Eldon, the age of which is uncertain.

ANALYSIS OF TASMANIAN COALS.

Colliery.	Basin.		Fixed Carbon.	Gases.	Ash.	Moisture.	Sulphur.
Spreyton	Mersey.....	Permo-Carb...	36.5	46.6	4.0	12.9	..
Dulverton.. ..	Mersey......	Permo-Carb...	40.5	44.4	5.8	9.3	..
Mt. Cygnet ..	Mt. Cygnet	Permo-Carb...	63.9	13.2	22.0	0.9	..
Mt. Nicholas..	Fingal	Mesozoic.. ..	57.5	28.4	9.3	4.3	0.54
Cornwall	Fingal	Mesozoic.. ..	55.0	31.0	9.6	3.9	0.56
York Plains—							
Upper seam	York Plain	Mesozoic	60.2	14.5	23.8	1.5	..
Middle seam	York Plains	Mesozoic	50.4	11.5	34.4	3.7	..
Sandfly—							
Top of seam	Sandfly.......	Mesozoic	46.5	23.0	28.0	2.1	..
12in. below..			53.1	29.9	15.6	1.4	.
Below preceding			54.3	25.4	17.6	2.7	..
Lower part of seam......			56.0	25.7	15.1	2.5	0.7
Semi-anthracite, 3ft. 6in. lower Sandfly measures..			80.0	8.0	9.0	2.2	..
Catamaran—							
Upper seam	Recherche...	Mesozoic.. ..	67.8	24.5	3.7	4.0	..
Lower seam	Recherche...	Mesozoic	65.6	27.7	3.9	2.8	..

8. W. H. Twelvetrees, Report on Country on the East Shore of Lake Sorell, and on a Discovery of Coal near Oatlands, 1902. By authority.

10. W. H. Twelvetrees, Report on the Coal-field in the Neighbourhood of Recherche Bay, 1902. By authority.

10. W. H. Twelvetrees, Report on the Occurrence of Coal near Catamaran River, Recherche Bay, 1902. By authority.

CHAPTER XI.

New South Wales Mining Conditions.

The largest area of land leased by the Government in one block for coal mining purposes is 640 acres. One can amalgamate two or more of such blocks together, so as to make a workable area, and concentrate all mining on one block, if desired. Although it is admitted that 640 acres is not sufficient to encourage a company to lay out money on an expensive plant, and there is nothing to prevent a would-be lessee from taking up several such blocks adjoining one another, still the Government insist on forcing those who wish to work on Crown lands to go to the expense of pegging out and having surveyed several comparatively small blocks when one large block should suit the purpose. For the purpose of mining under land reserved for coal mining, a charge of 1s. 6d. per acre per annum is made; but if the surface rights are also required, then 2s. has to be paid for each acre on that particular block. When it is desired to mine for coal under land not specially reserved for coal mining purposes, as is often the case for 100ft. back from high water mark, the rent is 5s. per annum, but for mining under tidal waters the rent is 1s. per annum. While coal is being won, a royalty of 6d. per ton is charged on round coal, and 3d. per ton on small coal, which, in comparison with the rent paid for mineral leases, is very excessive. Should the amount paid in royalty exceed the rent, then no rent is charged. There are also certain labour conditions to be kept up, which vary somewhat.

Until the passing of the Land Act of 1884, which abolished the power to take up mineral conditional purchases, known as M.C.P.'s, anybody improving his land to the extent of £2 per acre could become possessed of the rights to all minerals on the property, with the exception of the royal metal, gold. In some cases land was purchased under these conditions, and the improvement money put into plant for the mine and development work; so now they have neither rent nor royalty to pay, thus having an immense advantage over their neighbours who work on Government land, or that leased from private individuals. Landowners, who possess the mineral

rights, but who do not wish to work the coal themselves, make the most favourable arrangements they can with those who want to mine their coal. One cannot amalgamate adjoining private and Government lands; the labour conditions must be carried out on the latter according to the terms of the lease.

It is customary in the New South Wales collieries to work but one shift of eight hours a day, except for men engaged in development work. If the development work is not sufficiently far ahead, there may not be enough places opened up for men to win coal to fulfil contracts; also steeply inclined seams are not so readily developed as those that are more horizontal. For these reasons, about 10 years ago, the East Greta Colliery initiated three shifts a day, as is customary in metal mines, and the same system was adopted by the newer collieries of the Northern coal-field. The night shift, nicknamed the "dog-watch," was objected to by the miners, though each man's turn only came round every three weeks. He complained that he could not rest so well by day, especially in the summer time, with the heat, flies, and noise about him. His wife had to scheme so as to let the bread-winner sleep, rushing out to stop the tradesmen calling, and sending the children to play outside, away from her watchful eye. It is generally admitted that men working on night shift do not work so satisfactorily as on day shift, and on the southern coal-field the miners are paid 1½d. per ton extra for all coal hewn by them during the night shift. Another objection that the miners have to this shift is that there are six men in a party instead of two. Now the coal won is credited to the men obtaining it, not as individuals, but as sets, and the more men there are, the greater the difference there is likely to be in their individual capacity for work; so that unless they agree among themselves that the inferior men shall receive so much less, and the superior men so much more, than one-sixth of the total earned (a principle objected to by miners when working for wages, as they want all to be on a dead level), then the better men get dissatisfied. It is generally inexpedient to separate the work of the shifts working in the same bord, for time would be wasted in cleaning up the coal from each shift. The men are paid according to the coal sent to the surface in skips; one shift might put in hours undercutting and blasting down coal, which it would not have time to fill into skips; unless the following shift belonged to the same party, they would get credited for the coal the former shift actually won. Under these circumstances, miners naturally do not break down more than they can fill, and as they cannot always gauge the quantity, they may often be left idle for some time, rather than put in work for other men; besides, by making the work suit the time, instead of the time suit the

work this may result in uneconomical methods, and inability to take advantage of favourable conditions.

In many of the New South Wales mines they employ what is known as the front and back shift; that is, one of two mates comes on two hours before the other, while the latter remains behind two hours after the former goes home. This is done so that coal can be filled to keep the wheelers going, for the miners only work eight hours, while the wheelers work ten.

Personnel.

The positions and duties of officers and men employed at a colliery naturally vary somewhat, according to circumstance, such as whether it is pick or machine worked. In a large colliery the work may be subdivided, whereas at a smaller colliery one officer may carry out the duties of two or more positions.

The general manager attends chiefly to the business part of the colliery, and has his office at some central place. If not located at a shipping port, it may be necessary to appoint an agent to act as shipping manager. The colliery manager has to hold a first-class certificate; he has full control of the working of the colliery, and all officers and men employed in or about it. The under-manager must hold a second-class certificate; he has daily supervision of the mine, and has responsible charge of it, under the direction of the colliery manager. A deputy is in charge of a certain portion of the workings, and directs the men how and where they shall work, and attends generally to their safety. A fireman's duty is to test the workings for gas before the miners go to their working places, and see that everything is safe; this is often, but not always done by a deputy. A surveyor may be fully employed at one mine, or he may combine this duty with another, or sometimes he does the surveying for several collieries. The clerk attends to the correspondence, books and stores. The mechanical engineer, who is often also the electrician, is in charge of all the machinery.

The miner in a hand-pick worked mine holes or undercuts the coal, props up the roof of his working places, sprags the coal while holing, lays the rails in the bords, and fills the broken coal into skips by shovel or fork, according to requirements. In machine-worked mines the coal-cutter is in charge of a machinist, who has a man as second hand machine assistant, and a boy as a third hand assistant, to help him. The work of holing is followed up by a shooter and fillers, who bore shot holes in the coal with an auger drill, charge and fire them. The shooter brings down any loose coal that may hang up, and makes the place safe for the filler. From ten to twenty tons a day is considered a fair day's work for one filler, depend-

ing on the size of the seam and dirt to be picked out. The work of shooting down is the same, whether the coal has been holed by pick or machine. Wheelers are lads who drive the ponies that draw the skips to or from the working places and the nearest collecting station. If the wheeler has a bad road he is given the assistance of a helper-up, who puts in sprags and makes himself generally useful. Drivers are boys in charge of a horse and set of skips on a main roadway, where difficulties are not likely to be encountered. A set-rider is a man who accompanies a set of skips, hauled on the main and tail rope principle; he attends to any points on the track, and signals to the engine driver in case of accident. Trappers are boys sometimes employed to attend to the doors erected for ventilation purposes in roadways along which hauling is done. Flatters are men in charge of a flat or station underground where shunting takes place. Clippers-on and clippers-off fasten or unfasten clips connecting the skips with ropes when the endless rope system of haulage is employed. The on-setter has complete control of the pit bottom; he cages and uncages the skips at the bottom, and gives the signal to the engine-drivers to hoist. The banker-off or banksman attends to the caging of the skips at the surface. Water bailers are employed below in wet places where it is not always convenient to put a pump, such as at the end of a leading heading that is constantly going forward to the dip. Road-men are shiftmen who lay the tracks, see that they are kept in order, look after the timbering, and attend to various odd jobs below. Horse-keepers attend to the pit horses, whether the stables are on the surface or underground. A bricklayer is sometimes kept at a mine to build any walling, put in brick stoppings, overcasts, etc. Engine-drivers are in charge of various engines for hoisting, hauling, fan driving, pumping, lighting, etc. Stokers are required to attend to the boilers. There are mechanics, blacksmiths, and carpenters, for various repairing and constructional work. Lampmen attend to safety lamps, when they are used. Where many horses are employed a harness-maker is engaged to make and repair the harness. Screenmen look after the tipplers and screening of the coal; while weighmen weigh the skips and take their tally. The miners generally engage and pay a check weighman to look after their interests. Shiftmen are those engaged on wages at various jobs, and are rated as first and second class. These include such men as stowers, dirt-fillers, timbermen, and labourers. Top-men are any men employed about the surface.

Rate of Pay.

The rate of pay that colliery employes receive depends to a great extent upon the price of coal, but there are many

variations which modify the amount. These variations are not uniform all over New South Wales, for different customs prevail in different districts, and even the conditions may vary in collieries of the same district. The following remarks may help to make these points clearer.

On the Southern coal-field there are two rates; one for screened the other for unscreened coal, but both are based on the average selling price of the best screened coal, which is determined half-yearly, in June and December, by an accountant agreed to by the employers and employes' union, or, should they fail to agree, then by an accountant appointed by the Arbitration Court. The price thus found is the basis of pay for the ensuing six months. In the Maitland district the average selling price of best round coal is also taken as a basis in most of the collieries, but in the Newcastle district it is not the actual selling price, but the declared selling price of the best round coal that is the basis. Every September the employers meet and determine what the nominal selling price of coal shall be for the ensuing twelve months, commencing in January of the following year. This price is adhered to, no matter whether a mine produces first, second or third rate coal. Should the colliery proprietors sell their coal for less than the declared value, the men are paid on the declared value all the same.

A minimum hewing rate is fixed, say about 2s. per ton, when the price of coal is, say, 7s. Should the selling price fall so low as to leave no profit, the proprietors still have to pay the minimum rate or close down, for it is recognised that the men must make a living wage; on the other hand, the mine-owners do not wish to waste a valuable asset by selling their coal at a loss. Should the selling price go above the figure decided on, then there is a sliding scale, on which the men are paid; in the Southern district this is at present 2d. in the shilling variation of the actual average selling price; in the Northern districts they pay on 6d. or 3d. variations.

At one time the miners filled a good deal of coal by fork, but now that there is a better market for slack, it is mostly shovel-filled, and subsequently screened. Fork-filled coal is paid for at a higher rate than shovel-filled, so as to allow for the slack left behind. When the slack from fork-filled coal is wanted, a miner is paid only for filling it, and the miner who made the slack has the right to fill it, if still working in that cavil. When coal is screened, the men are paid in full for the round coal, but are only given a nominal sum for the slack. When coal is shipped unscreened, the miners are paid the price of round coal for the gross weight, less, say, 20

per cent. for the proportion of slack present. Pillar coal being easier to work than coal in the whole, the tonnage rate paid for it is somewhat less.

A standard height of seam is taken, say 5ft., and should the seam fall below that standard the miners are paid so much more for every inch below that height, for it is obvious that there is just as much work to undercut a 5ft. as a 4ft. seam, and yet the tonnage obtained would not be the same. Should the seam be over the standard height, the men are not paid any less, although it is admitted that a 6ft. seam is an ideal one to work; but should the seam be still thicker, it is not so convenient to break down, for the men have to work it in two or more lifts.

Extra pay is given for what is known as a "deficient place;" that is, one which is not a fair average; but as the nature of these places vary, it is a matter of adjustment between the manager and the men concerned.

Development work and difficult places are known as "special places," and they are carried on irrespective of trade.

In the Borehole seam there are two consistent bands running through the coal; the price paid for hewing and filling allows for these to be picked out by the miner. A certain proportion of dirt gets filled in with the coal, but it is clear that this must be limited, or else complaints will be made by consumers. Boys generally overhaul the coal and pick out pieces of band before it is sent away in the waggons. Should it appear that a pair of men are sending up too much dirt, one of their skips is tipped on to a special screen, and the dirt is picked out by a man engaged for the purpose, who becomes the best hated man at the mine. The dirt picked out is either weighed or measured, according to custom; in the latter case one and a half bobbinite cases, or, say, a cubic foot, is allowed to pass, but if in excess of this, the man is cautioned the first time, unless he can give some good reason; if he persists in filling dirty coal, then he is suspended for a day or more, according to the extent of the offence.

If extra bands occur, the miner is paid for sorting it out. The quantity of extra dirt picked out is generally agreed upon between the manager and the men, but if the latter are not satisfied, they can have it weighed at the surface.

A consideration is also paid the men working in wet places, say, up to 1s. per day extra. A wet place may be one where the men have to stand in 3in. of water, or where water is constantly dripping on their bodies from the roof.

Working places less than 18ft. wide are known as "narrow places," and a yardage rate is paid, in addition to the tonnage

rate, in order to compensate for the extra work of breaking coal down from the sides, which for the same tonnage occurs more frequently than in wide places. The amount of yardage paid varies according as the width is from 0 to 9ft., 9 to 12ft., 12 to 15ft., or 15 to 18ft.

No deduction is made for moisture in the coal, this being weighed as coal and credited to the miner. It is reckoned that if there is only a little water present it is as cheap to fill it out with the coal as to employ a bailer to remove it. In such cases it is as well not to have the skips close fitting, otherwise too much water may find its way in, and be retained by the skip. It is not much use drilling a hole or two in the bottom of a skip, as these can be plugged up with bark, paper, etc.

Machine-mined coal is filled into skips by special fillers, for to take men from the machine would lay the machine idle, and be putting highly paid men to do inferior work; besides the output would be reduced, and the capital expended on the machine and plant would be lying idle. Hand-mined coal is filled into skips by miners. The top of the skip is packed all round with large pieces of coal, which are not so likely to fall when done by a practical miner as when done by an inexperienced hand. When the top falls off through bad packing, the miner is not credited with the full amount originally placed on the skip, but if, through some accident, such as a capsize, the coal falls out, this is known as a "copt." "upset," or "broken skip," the wheeler in charge should mark it, and report it to the flatter, who initials it, or places a special token on it, so that when it reaches the surface the weighman, knowing it is no fault of the miner, credits him with the average of other skips sent up by him. In low places a skip cannot be loaded so full as where there is no restriction in height. Each skip is marked with a token. This consists of a small piece of leather, threaded on to a long loop of marline. The loop is passed through two small holes in the end or side of a skip, and the leather tag passed through the loop and pulled tight. When the skip is full of coal the token can be readily pulled out, but cannot be replaced without partly unloading and reloading again, and as this cannot be easily done while the skip is in transit, the chance of one man stealing a skip load belonging to another is minimised. However, sometimes a man runs short of tokens, in which case he chalks his number on the skip. This custom has its disadvantages, for it enables an unscruplous man to draw out the token of another and substitute his own chalk mark. To prevent this, the token is sometimes hung inside the skip, with a lump of coal against it, and more on the top;

but even this has been known to have been tampered with when a miner has left a loaded skip overnight. Each party of men takes a bundle of tokens to their working place, sufficient for their daily requirements, the number on the token representing that cavil.

Machine men are generally paid wages, but are sometimes paid tonnage rates. In the former case the wages vary with the price of the coal. All wages men benefit by an increase in the price of coal, but the interest of shiftmen and wheelers varies in degree from that of the miners, according to custom.

Wheeling may be done by contract or on wages. If the former, and the mechanical haulage is not brought within a reasonable distance of the working places, the price when paid by tonnage may be, say, 2d. for the first 130 yards, and ¼d. for every additional 30 yards. Wheeling from isolated places, where work is not constant, is done on wages, as when there is no wheeling to be done the lads can be put on to other work.

Cavilling is a lottery, so far as the securing of places is concerned. It is a North of England custom adopted in New South Wales, the original idea being to average the advantages and disadvantages of good and bad places, for the men are paid the same tonnage rate in either case, except in what are known as special places, when they are paid extra. A man may draw a good place two or three times running and make more than good wages, or he may be unfortunate and draw bad places two or three times in succession, which do not pay wages, however hard he works. Although the good and bad may average out in the long run, still in the meanwhile an improvident man who has been unfortunate in his cavilling may be unable to make ends met. This has caused a certain amount of discontent, and although cavilling is carried on at the desire of the miners, they want it to be modified, so that those working in bad places shall be paid a higher tonnage rate. This is obviously unfair, unless those working in good places receive a proportionately lower tonnage rate, to balance matters. There are other objections besides the discontent engendered among those who draw bad places. A man, no matter how good a miner he may be, takes some days to become thoroughly conversant with the peculiarities of a new part of the mine, so that he can work with confidence, guard against any local dangers, and take full advantage of any special points. The consequence is that for a short time after cavilling the output is diminished, which is unsatisfactory both to the men who are paid by the ton, and the masters who have contracts to carry out.

Every quarter, the different working places to be cavilled for are chalk-marked with a number; similar numbers are written on paper and placed in a hat, or hurdy-gurdy, likewise the names of the men. Two miners, called scrutineers, draw the papers in the presence of the undermanager. The men generally work in pairs, but special cavils may require four men. The special cavils are drawn first. The manager has a right to object to a member of a special cavil if he does not think the man is good enough for the work. Those men who are drawn for any place work there till the end of the quarter, or till the place is worked out, when, in the latter case, they are given the next nearest vacant place. Should several places be worked out about the same time, an interim cavil is held. Sometimes places worked by machines are cavilled for, but generally the men are paid wages. The shooters and fillers, however, cavil for places.

Accident Relief Fund.

In New South Wales the Miners' Accident Relief Act, 1900, and the Miners' Accident Relief (Amendment) Act, 1901, applies to any mine in or about which fifteen or more persons are employed. For each mine a committee is formed, consisting of an Inspector of Mines, appointed by the Minister, three persons employed in or about the mine and appointed by persons so employed, and two persons appointed by the owner or manager of the mine. Every person employed must subscribe 4½d. for each week, or portion of a week, during which he is employed; the mine-owners have to subscribe 2¼d. for each man, while the Government donates 2¼d., making a total towards the fund of 9d. per week for each man or boy employed about the mine. Should an employe meet with a non-fatal accident he receives a weekly sum of 12s., and should the disablement be permanent a further allowance of 2s. 6d. per week is payable in respect of each child (if any) of the person disabled, until such child attains the age of fourteen years or dies. In case of fatal accidents, a sum of £12 is paid for funeral expenses, the widow (if any) of the deceased gets 8s. weekly while unmarried, and 2s. 6d. in respect of each child (if any) of the deceased is paid to the widow or guardian of the child till the child attains the age of fourteen years or dies. Provision is also made to pay 8s. per week to the guardian of motherless children until there is no child below the age of fourteen years, or to the mother, sisters or father of the deceased if they were dependent on the deceased at the time of his death.

As the existence of such a fund is liable to encourage malingering with lazy men, certain precautions are made to

safeguard the fund, which exists for the benefit of the workers. It is by no means certain that these precautions are sufficient, and there are cases where the committee have grave suspicions that the benefits of the fund have been abused; but when a certificate from the local doctor, who is dependent on the miners for his living, is produced, to prove the man is unfit for work, the committee is helpless. One thing is noticed by managers, viz., that more accidents are reported than formerly, and that the men take longer to recover. No doubt a travelling doctor, available for doubtful cases, would cure the victims quicker.

Selling Agencies.

The Northern, Southern, and Western coal-fields each have combinations bearing on the disposal of their output. Some mines prefer to associate together, and have one selling agency, while others prefer to find their own markets. The advantages of a selling agency is that it saves each mine time and trouble in searching for a market. It limits the cutting down of prices, so the mine-owners get more for their coal. It is not always easy for one mine to supply large quantities right away on short notice, and the want of facilities may oblige a mine to refuse a large extended contract; but when several collieries combine together they can help one another to fulfil such contracts, and consequently trade is not lost. The mines belonging to such selling associations are worked and managed by their owners; each mine is apportioned a certain amount of the contracts obtained, according to its capacity. If a buyer specifies coal from a particular mine, then that coal is supplied, but so as to balance matters, that mine is given a smaller proportion of other contracts.

The Northern coal-field has formed a vend, with the object of regulating the coal trade. This affects all the large Northern coal mines, except the Newcastle-Wallsend and Burwood Extended collieries. Some years ago a somewhat similar arrangement was come to, but some of the conditions were broken, and those at fault refused to pay the stipulated penalty. An attempt made to recover the penalty in the Supreme Court was unsuccessful, as it was held that since the agreement was in restraint of trade, it was therefore illegal. After this, competition set in as before. Later on a standard selling price for coal was adopted, so as to afford a basis for a uniform hewing rate on which to pay the mines. but the standard selling price was no criterion as to the actual selling price.

The vend formed in October, 1906, to last for a year, had many difficulties to overcome, for conflicting interests had to

be reconciled, not only for the present, but also for the future. The average capacity of all the collieries was greater than the average demand, and naturally the most difficult matter to settle was the proportion each mine should contribute. If in the proportion of the average output of each mine for the previous three years, it placed those mines at a disadvantage which were being developed and were rapidly building up a trade, when compared with older established mines; so a certain readjustment was necessary. Provision was made for penalties to be paid by those companies who exceeded their allotted output, the sum thus obtained to be paid into a common fund, and the money so accumulated used to compensate the owners of those mines who failed to get orders for the tonnage allotted to them. Though the agreement cannot be signed, as it is probably contrary to the provisions of the Commonwealth Anti-Trust law, still the parties consider themselves honorably bound to respect the arrangement, and funds have been contributed to guarantee their observance. As the coal from the various collieries is not of the same quality, three classes are recognised. The first grade coal at the commencement of 1907 had a standard selling price of 10s. per ton. All the Maitland mines, except one, and all the Newcastle mines, except two, yield first grade coal. The second grade coal has a standard selling price of 9s. 3d. per ton. The third grade coal, which comes from the Teralba mines, is valued at 3s. or 4s. less than the Newcastle coal. The rates of compensation and penalty varies according to the classification from 4s. per ton downwards.

By an agreement of this sort, individual competition between mines in the same district is lessened, and this enables the mine-owners to demand a price, within limits, that will give a fair interest on the outlay. For oversea coal there is always foreign competition to be taken into consideration, while for home consumption the product from other Australian coal-fields will tend to keep prices within bounds. So long as members of the vend can supply more than the demand, it is naturally to their advantage to suppress competition by those outside their ring; this they can easily do if they exercise the power at their command by underselling a competitor. Thus by selecting certain collieries to supply coal of a similar quality at two or three shillings less than the tender of the company they wish to fight, the other members of the vend can make up the difference to their friends, who secure the tender, from a general fund, to be maintained by levies of so much per ton. In this way a loss becomes light to the combine, which might ruin a single company. To control the vend, boards are established, both in Newcastle (N.S.W.) and London. In the past, prac-

tically all the foreign business has been transacted through London, where the different collieries had their agents, who attended to the chartering, etc.; now the individuals will have to act according to the decision of the board instead of on their own responsibility.

The vend has also agreed with four shipping companies, viz., Howard Smith Proprietary Company, the Huddart, Parker Proprietary Company, the Adelaide Steamship Company, and Messrs. McIlwraith, McEacharn and Company, that they only shall be supplied with coal intended for consumption in Victoria, South Australia, West Australia, and Queensland. This excludes Messrs. Scott Fell and Company, James Patterson and Company, and the Melbourne Steamship Company, who, together with the favoured four, have had the freighting of coal to other States largely in their hands.

The Southern Coal-Owners' Agency represents the following collieries:—Mount Kembla, Mount Pleasant, Osborne-Wallsend (Mt. Kiera), Coal Cliff, and the Metropolitan. In the hands of a good business man and a man of tact, this agency should be the means of benefiting both the mine-owners and miners, and indirectly the district, by opening up fresh markets and limiting competition. For some years Scott Fell and Co. will have the control of the output from South Clifton. G. S. Yuill and Co. dispose of the output from the Bulli and Corrimal-Balgownie collieries; while the North Bulli or Coledale and the South Bulli-Bellambi collieries each act as their own agents.

The Lithgow Coal Association is the selling agency for the five principal collieries at Lithgow, viz., Oakey Park, Zig-Zag, Vale of Clwydd, Hermitage, and Lithgow Valley. This association not only provides most of the coal used in the Western district, but is expanding trade by shipping coal from Darling Harbour.

Shipping Facilities.

Some of the coal from the South Coast goes to Sydney for shipment, and naturally all the coal from the western field for export finds an outlet at Darling Harbour. This coal is shipped from the Pyrmont wharves, of which there are two, with four berths; two are 500ft. long, and two 470ft. long, the depth of water at low tide being 25 to 28ft. There is a 15-ton steam crane at three of the berths. A train of hopper trucks is run down near the ships, and two trucks are drawn at a time by horses which fetch them opposite the steam crane. It takes three minutes to hook on the body of a truck, hoist, empty, and replace it. At this rate, as each truck is supposed to hold ten tons, they should load 200 tons an hour, but 150 tons is nearer the actual mark. Fig. 29.

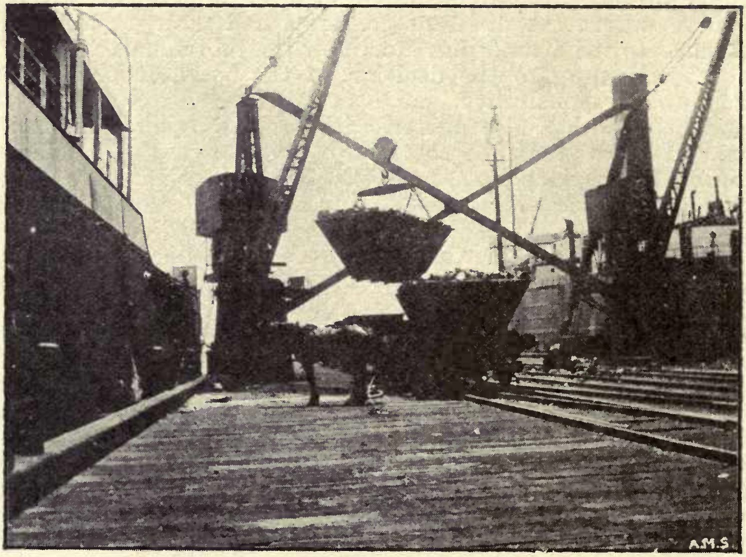


Fig. 29.—Pyrmont Wharf.

The D style of trucks hold from 6½ to 32 tons, generally 10 tons. From their nature the coal has to be shovelled out of them, so they are only used for home purposes, not for shipping coal.

The Coal Cliff colliery has a private jetty close to its mine, and up to now all coal has had to be shipped from this jetty. At high tide there are 18ft. of water, and at low tide 13ft. This jetty accommodates the company's 300 ton boats, which are loaded by means of the usual shoots. The S.E. wind is the one most dreaded here, as it brings in the heaviest sea; the N.E. wind generally goes down with the sun.

The Bulli colliery's jetty, which is but slightly protected from the south, was destroyed in 1907, and is now in course of re-erection.

The Bellambi, or South Bulli jetty, is owned by the Bellambi Coal Company Limited; from this 500 tons per hour can be loaded into vessels. At low tide the depth of water is 22ft. The coal from the Company's mines is mostly sent away by sea. The company owns four steam colliers, the Malachite, 680 tons; Currajong, 500 tons; Werfa, 1180 tons; and the Marjorie, 1250 tons. Besides their own coal, the company also ships coal from other collieries at their jetty, and inter-State steamers also load here. The trucks pass over

a Fairbanks platform scale on their way to the jetty, the weight thus found being accepted by the buyers. There are two tipplers for the trucks: one for the black trucks only, which has a catch to work the trigger that opens the end door of the truck; the other at the end of the jetty, that serves for either black or hopper trucks; as the hopper trucks are longer than the black trucks, swing rails are let down to allow the bottom of the truck to be over the shoot leading to the ship's hold. There are two roadways on this jetty; the upper one, for the loaded trucks, is 1630ft. long, while the lower, which serves for the empties to return on, is 1230ft. After the full trucks are left on the upper line, they are hauled to the shoots by ropes attached to winches. The jetty was being repaired at the time of my visit, a truss being used to span the space, while a bent was being renewed, and this truss supported the sleepers and rails. The legs of the bent are dowelled into the solid rock. The bunkers for small coal at the jetty hold 700 tons. There is a very complete water system laid on, with standpipes at convenient intervals, in case of fire.

At Wollongong, the Belmore Basin (Fig. 30) has been for the most part cut out of the rock; it has an area of about three acres, and an average depth of 14 feet. Mostly coasters load here, the coal being sent down shoots into the holds.

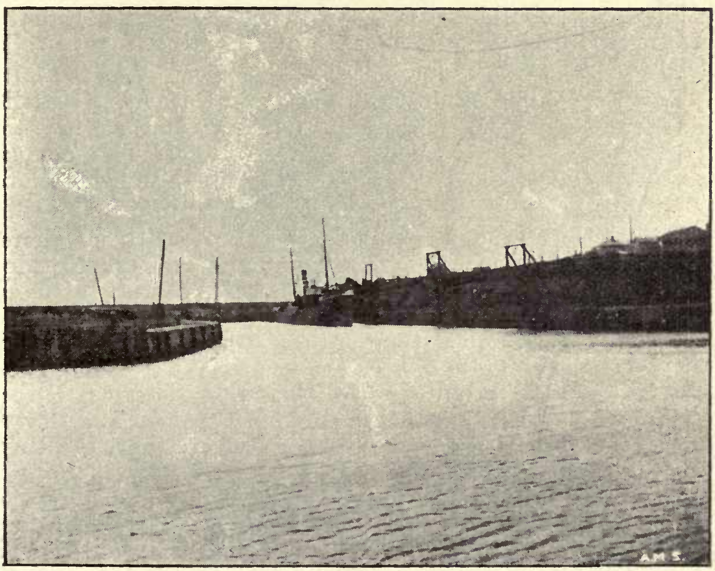


Fig. 30.—Belmore Basin.

Only small sailing craft and steamboats can enter this basin, as no tugs are kept at Wollongong now. The shoots into which the hopper trucks are emptied are raised and lowered by hand-worked crab-winches. The loading capacity is about 1300 tons per day.

Port Kembla is the best shipping port on the southern coast. There are two jetties; that known as the Southern Coal Company's jetty, with three loading shoots, which is leased by the North Bulli Colliery, has 35ft. of water during low tide at its outer end. The Mount Kembla Coal Company's jetty, with two shoots, has 24ft. of water. A breakwater is being built by the Public Works Department, which, when completed, will be 2800ft. long; about 1450ft. of it has been made. When this will be finished largely depends on what funds are available. For some time the work has cost more than it should, because the construction has been starved for want of funds, and consequently some of the men who must be kept on have not been fully employed. It will take at least another four years to complete, as the last half is the deepest. It is proposed later on to build a second breakwater, 3600ft. long, in an easterly direction, almost at right angles to the one now being built. When completed, this will leave an entrance 800 feet wide, and give an area to low water of 223 acres; or of water 24 feet and over, 126 acres. Until this harbour is completed, there will be risks of delays in shipping, in addition to the extra cost of railage to Darling Harbour.

The Wallarah Colliery has a jetty in Catherine Hill Bay, at the end of which there are 25ft. of water at low tide. There are four loading shoots on this jetty. The company owns two colliers, the Wallarah of 750 tons, and the Illaroo of 500 tons.

Newcastle Harbour is part of the Hunter River. There is a bar at the entrance, where the water is only 22 feet deep. Vessels of 8000 tons can be berthed at Newcastle. It is estimated that, after allowing for time in moving ships, shunting coal trucks, etc., 25,000 tons of coal can be shipped per day at the port, when all appliances are in use. At Newcastle there are 2066ft. along the dykes for berthing deep draft cargo vessels. At Bullock Island there are 5550 feet set apart for the shipment of coal. At New Basin wharf, where there is a travelling crane, there are 600 and 700 feet. At Stockton there is a length of 600 feet for the shipment of coal. The A.A. Company's wharf at Newcastle is 1500 feet. McMyler coal dumping machines are being erected at Newcastle, each of which will be capable of dumping 500 tons of coal into a ship, as against 100 tons by the present cranes.

The output from the New South Wales coalfields for 1909 was as follows:—

	Tons.
Northern Field	4,801,361
Southern Field	1,619,675
Western Field	598,843
	7,019,879

of which 4,393,603 tons were shipped to inter-State and foreign ports.

Fig. 31 shows the gantry used at South Brisbane for loading coal into vessels.

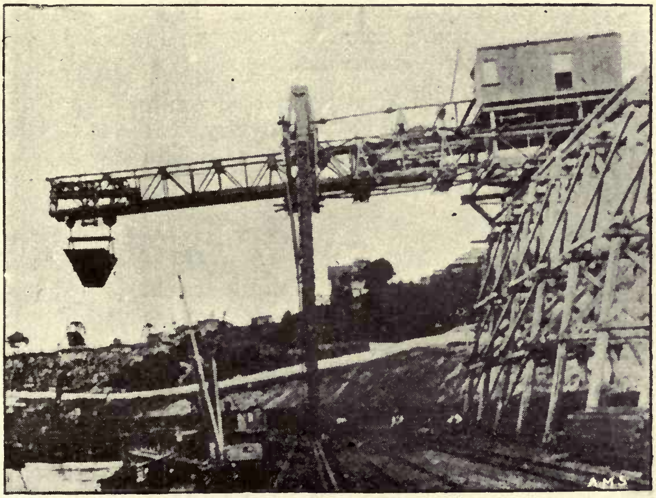


Fig. 31.—South Brisbane.

CHAPTER XII.

EXPLOSIVES.

In New South Wales the permitted explosives are the same as those allowed in Great Britain. There are about sixty of them, but only some seven are on the local market, and most of them find little or no use.

The composition of those permitted explosives which are pushed out here, as given in "Statutory Rules and Orders," issued by the Home Office, London, is as follows:—

Monobel.

	Parts by weight. not more than	not less than
Nitrate of ammonium	82	78
Nitro-glycerine	11	9
Wood meal (dried at 100deg. C.)	10	8
Moisture	2.5	0.5

Saxonite.

	Parts by weight. not more than.	not less than.	not more than.	not less than.
Nitro-glycerine	68	58		
Nitro-cotton	5½	3½		
Nitrate of potassium	30½	27½	91	73
Wood meal	8½	5		
Chalk	½	—		
Oxalate of ammonium	—	—	27	9

The wood meal to contain not more than 15 per cent., and not less than 5 per cent. by weight of moisture.

Kolax.

	Parts by weight. not more than.	not less than.
Nitro-glycerine	26	24
Nitrate of potassium	27	25
Nitrate of barium	6	4
Wood meal (dried at 100deg. C.)	32	29
Starch (dried at 100deg. C.)	10	8
Moisture	6	4

Bobbinite.

Second definition.	Parts by weight. not more than.	not less than.
Nitrate of potassium	66	63
Charcoal	20.5	18.5
Sulphur	2.5	1.5
Rice or maize starch	9	7
Paraffin wax	3.5	2.5
Moisture	3	—

This explosive is made by Curtis and Harvey.

Arkite.

	Parts by weight. not more than.	not less than.
Nitro-glycerine	54	51
Nitro-cotton	4	3
Nitrate of potassium	23	21
Wood meal	8	6
Chalk	½	—
Oxalate of ammonium	16	14

Abbcite.

	Parts by weight. not more than.	not less than.
Nitrate of ammonium	82	78
Nitro-glycerine	11	9
Wood meal	10	8
Moisture	2.5	1.5

Carbonite.

	Parts by weight. not more than.	not less than.
Nitro-glycerine	27	25
Nitrate of barium Nitrate of potassium	36	30
Wood meal	42	39
Sulphuretted benzol	½	—
Carbonate of sodium Carbonate of calcium	½	—

Rippite.

	Parts by weight. not more than.	not less than.
Nitro-glycerine..	62.5 ..	.. 59.5
Nitro-cotton..	4.5 ..	.. 3.5
Nitrate of potassium	20 ..	.. 18
Oxalate of ammonium	11 ..	.. 9
Castor oil	1.5 ..	.. 0.5
Wood meal (dried at 100deg. C.)	5.5 ..	.. 3.5
Moisture	1 ..	.. 0

Excellite.

	Parts by weight. not more than.	not less than.
Nitro-glycerine	9 ..	.. 7
Nitrate of ammonium..	84 ..	.. 80
Collodion cotton..	1.5 ..	.. 0.5
Di-nitron toloul..	3.5 ..	.. 2.5
Wood meal (dried at 100deg. C.)	4.5 ..	.. 3.5
Castor oil..	1.5 ..	.. 0.5
Moisture	2.0 ..	.. 0

The chief requirement of a safety explosive is that it shall not produce a flame, which might ignite any fire-damp or fine coal dust present. Of the above, monobel and saxonite find most use in New South Wales collieries; monobel being employed for breaking down coal, as it has a slow rending action favourable for producing lump coal, while saxonite is used for blasting rock, as it shatters hard rock better. In wet places saxonite is sometimes used instead of monobel for coal, as the nitro-glycerine in its composition makes it less liable to be hurt by moisture, but anyhow the monobel cartridges are dipped in a special wax to preserve the explosive from the action of moisture. Monobel is light yellow in colour, and is made into cartridges of various sizes, packed in cardboard packets, containing 5lb., and ten of these packages are placed in a wooden box. Its strength is reckoned to be at least 2½ times that of blasting powder, which means that for the same amount of work, less explosive and smaller holes are necessary. This explosive is not ignited by a spark, it does not require thawing in cold weather, and it does not give headaches like those compounds containing large quantities of nitro-glycerine. It is exploded by a sextuple, or No. 6 detonator. In a fiery mine, monobel is exploded by means of

an electric shot firer. Low tension electric detonator fuses are used; these are packed in cases of 1000, and have wires attached 48, 54, 60, 72in. and upwards in length, according to the depth of the hole. A broad red line is made at one end of the cartridge, where there is an excess of paper; this end is opened, a hole is made in the explosive by means of a pencil, or small pointed stick, deep and large enough to completely bury the detonator when lightly pushed in; the loose paper is then tied over the detonator-fuse-wires with a piece of twine to prevent withdrawal of the detonator from the explosive. A good plan is to reverse the cartridge, bend the wire round, and give it a half hitch round the cartridge. The half hitch prevents the detonator from being pulled out accidentally, and the wire is led up the side of the hole, at the same time the detonator is protected between two cartridges, and there is less danger of a premature explosion due to careless stemming.

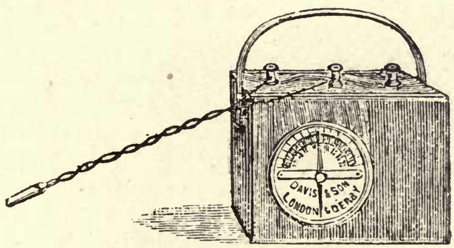


Fig. 32.—Galvanometer, with Testing Battery.

The tamping should be damp clay, the first two or three pieces being pressed gently home, and the remainder rammed fairly hard with a wooden rod, as this is less likely to damage the wires than one tipped with copper. The electric fuses should be stored in a dry place, and care should be taken not to kink or twist the fuse wires in such a way as to cut the insulation and render the fuse useless, this being especially important in wet ground. So as to prevent miss-fires, each fuse should be tested before being used. This is done by placing the fuse in an iron pot or pipe for protection in case of accidental explosion; it is then connected to a galvanometer (Fig. 32) by pressing the bared end of the fuse wires on to the knife edge terminals of the galvanometer with the fingers, care being taken that the ends of the wires do not touch each other. If the needle moves, the fuse is good, but if it remains

stationary, the fuse is defective, and must be discarded. Each fuse must be tested separately, and the galvanometer must stand on a firm basis, so that it does not get shaken, when in use. The ends of the fuse and cable wires should be bright and clean; they are twisted together in such a way that they are in close contact, and cannot be drawn apart when pulled about. To ensure continuity of insulation, and obviate risk of loss of current, which is very important in simultaneous shot-firing, and in wet ground, the joint may be covered with prepared rubber taping, or some similar substance. Generally when shooting down coal only one shot is fired at a time, so as to reduce the amount of dust made. In cases where several shots are fired at the time, the fuses are connected up in series (Fig. 33). There are different types of exploders which are practically small hand dynamos. The connection between the

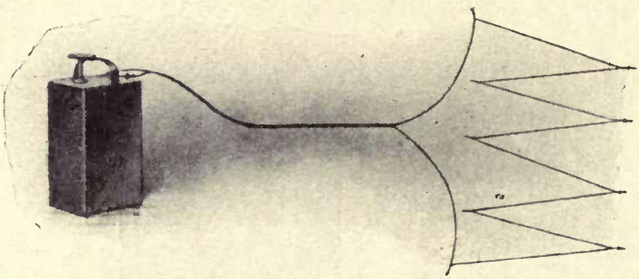


Fig. 33.—Holes Connected in Series.

cable and the exploder is not made till everything is ready for firing. As soon as the shots are fired, the cables should be disconnected from the exploder, and freed from any rubbish that may have fallen on them, after which they are coiled up out of the way. In case of a miss-fire, the tamping and charge must not be drawn, but another hole must be drilled parallel with, and at least a foot away from it. Before firing, the fuse of the miss-shot should be attached by means of a piece of string to some object, such as a prop, or the cable, which can be readily found later. Immediately after firing, the shot-firer must search the coal or stone with his hands only, for the detonator, so as to avoid the risk of filling it out with the broken material. The construction of a low tension fuse is shown in Fig. 34. The thin iridium-platinum wire is made red hot when the current passes through it, and this fires the priming. Low tension fuses are cheaper, safer, and less likely to deteriorate than high tension fuses, and have a further advantage, inasmuch as they can be readily tested without being

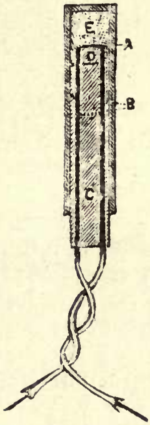


Fig. 34.—Fuse.
A—Platinum Bridge.
B—Copper Wire.
C—Plug Holding Fuse.
D—Primary Composition.
E—Charge of Fulminate.

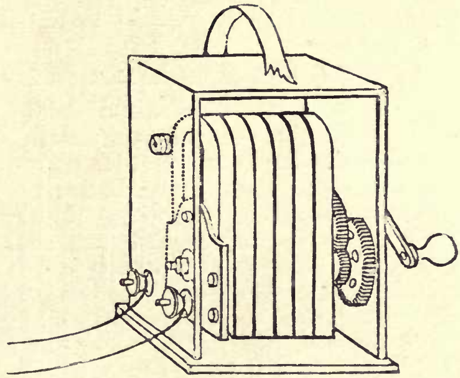


Fig. 35.—Magnetic Exploder.

destroyed. One of John Davis and Sons' magneto-exploders is shown in Fig. 35. Exploders are classified according to the number of shots they can fire at a time.

A five-foot seam in an eight-yard bord, when undercut, may require three shots to fetch down the coal; one in the middle, and one on either side on the top, the holes being given an upward slant. Thick seams require more shots to fetch down the coal than thin seams; also more powder is required for shooting when the holing is done in the top of the coal instead of in the bottom. Custom requires that the shooters find their own powder, but it is stored at the mine. Sometimes coal is shot down without holing: this is known as "shooting fast."

CHAPTER XIII.

New South Wales Western District.

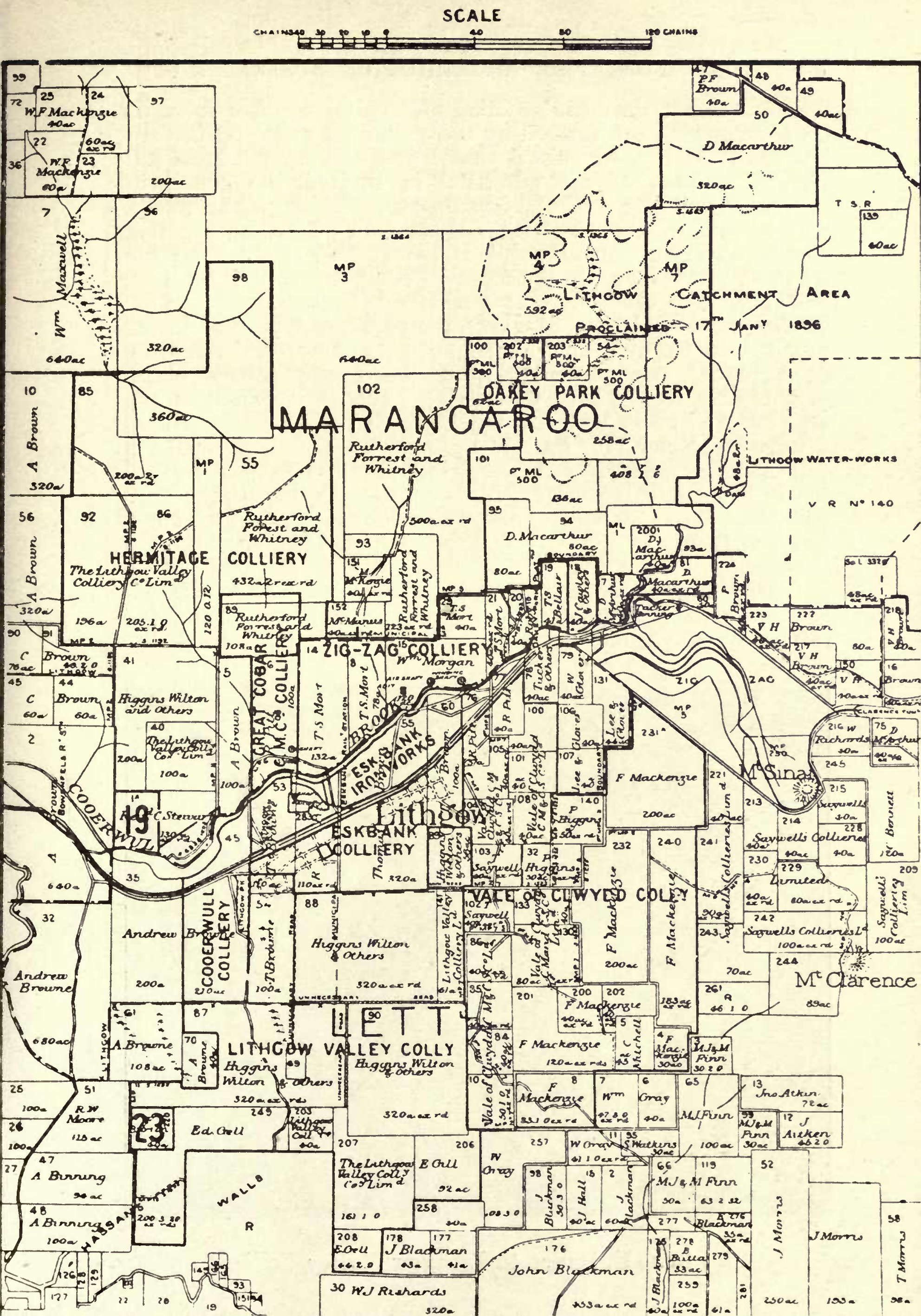
The coal lands in this district (Fig. 36) are either freeholds belonging to the companies that work them, or are leased from the Government.

The seam worked has better coal in the middle than top and bottom, where it is dirty, though individual bands of coal are good in the top and bottom coal. With the exception of the colliery owned by the Great Cobar Limited, only the middle coal is worked. The top coal makes a good roof, and above that the true sandstone roof stands well. The coal contains pyrites, not as nodules, but as films in partings and cleavages, as if it had been painted on. In this form it offers no difficulty in winning the coal. The facings in the coal do not continue for any great distance, though occasionally a main facing is met with, but these occur too far apart to be systematically made use of. The coal is too jointy to hole in for more than fifteen to eighteen inches, and rarely three feet. No shooting is required, and if powder was used, the force of the explosive would be largely expended in the numerous joints. Rolls or washaways are found confined to the coal, which do not extend to the roof or floor. The mines are not wet, but the coal is moist, so no dust is formed. The coal is not subject to fires, neither is firedamp found, so naked lamps are used for lighting purposes. Those collieries at the western end of the valley are worked from tunnels, while those at the eastern end are worked from shafts.

Besides the seam of coal worked, which thins out at the edge of the basin (first the top coal and then the rest of the seam, giving place to a carbonaceous shale), there is a poor splint coal, one to two feet thick, about 50ft. higher up, also another seam about 250ft. higher still, but neither of these seams are any good about Lithgow, though they become better near Wallerawang.

The Lithgow Valley Colliery.

This colliery belongs to the Lithgow Valley Colliery Company, which also owns the Hermitage Colliery. They are both under the management of Mr. J. Campbell, who has been in the company's employment for twenty-six years. For the past twenty years he has been manager, that is since the death of the former manager, who was unfortunately killed by fumes caused by a fire in the Lithgow Valley Colliery, that was started by an underground boiler igniting the coal near it. The miners played water on the fire and filled it


SCALE
CHAINS 40 30 20 10 0 40 80 120 CHAINS
MARANGAROO
LITHGOW CATCHMENT AREA
PROCLAIMED 17TH JANY 1896
OAKEY PARK COLLIERY
LITHGOW WATER-WORKS
V R Nº 140
HERMITAGE COLLIERY
The Lithgow Valley Colliery Cº Lim
ZIG-ZAG COLLIERY
Wm Morgan
GREAT COBAR M.Cº COLLIERY
ESKBANK IRONWORKS
FARMERS CREEK
COERWUL
Lithgow
ESKBANK COLLIERY
VALE OF CLWYDD COLLY
COOERWULL COLLIERY
LITHGOW VALLEY COLLY
Higgins Wilton & Others
LETT
Mt Sinai
Mt Clarence
Sawyells Collieries
D Macarthur
Rutherford Forrest and Whitney
F Mackenzie
Andrew Browne
WALLS
J Blackman
John Blackman
J Morris
WJ Richards
W F Mackenzie
Wm Maxwell
A Brown
MP 3
MP 4
MP 7
592 ac
640 ac

out, but either the heat distilled off explosive gases from the coal, or gases were formed by the action of water on the red-hot coal. It is well known that when making producer gas, if the amount of air admitted is limited, the generation of carbon dioxide (CO_2) commences at 750deg. F., and is formed exclusively at about 1300deg. F. At a higher temperature combustion takes place too quickly to be complete, so the poisonous carbon monoxide (CO) is formed, while at 1800deg. F. this gas is exclusively generated. When steam is added at a high temperature, it is decomposed into oxygen and hydrogen. Anyhow, an explosion took place, and probably both the above causes played a part in it. That portion of the mine was sealed off by an arched wall, with the convex portion turned inwards. Since it has been re-opened no signs of a fall has been discovered which could have caused a wind blast; besides, this colliery, in common with the others in the Lithgow Valley, is not a gassy mine, naked lights being used in all of them; so the explosion must have been the result of the fire.

The mine is worked from tunnels. There is one intake and main haulage road (Fig. 37) over a mile long, and two return air ways, one on either side of the intake, all driven

Fig. 37.—Entrance to Lithgow Valley Colliery.

in the coal from the outcrop. The coal is extracted by the pillar and bord method. The neck to a bord is made five yards wide for two yards, and in the next four yards it is gradually widened out on either side to the full width of the bord. namely, eight yards, or room for two men. The coal is found to stand better than when widened out suddenly.

The ventilation is carried out by means of two furnaces, one in each return airway, which terminates in a short stack. An air passage between the furnace and coal prevents the latter from catching alight. As this passage has no connection with the stack, no air can be drawn through them for ventilation purposes. The stoppings are of brick, built up of two rows of stretchers side by side, which break joint, and are bound together with two rows of headers in the total height. The top of the stopping is only one brick thick.

The hauling is now done by an endless rope, which rests in jockeys above the skips. The life of a tail rope is less than that of an endless rope, as it is never out of the mine, and is subject the whole time to moist air and gases, besides, it

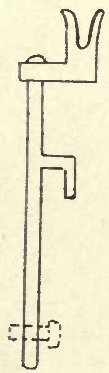


Fig 38.—Jockey.

winds up over itself on a drum, and so becomes crushed. The oldest part of the present endless rope is four years old, but two lengths have been added to it since. Twenty-pound rails are laid, on which the skips run singly, not in sets, at a speed of two and a-half to three miles per hour. Rollers are placed between the rails for the rope to rest on when not lifted off by the jockeys. This system is only good for straight roads with light, even grade, as is the case in this mine. The skips are released from the rope automatically, so no clippers-on or clippers-off are required. If a skip gets off the track, the rope is lifted out of the jockey and just runs on the top of the coal, doing no great harm. Two jockeys are used (Fig. 38),

both being placed at the back of the skip, for at the other end is a door, through which the coal is unloaded (Fig. 37). The longer jockey is used when the skip is full, so as to keep the rope above the coal. The shorter jockey is used when returning empties, for if the longer one was employed, as the empty skip is light, the greater leverage would tend to pull it over. The endless rope being worked above the skips instead of below, as is usual, it is easily raised out of the jockey automatically by causing it to pass over a pulley, which takes the weight off the jockey, so there is no fear of the skip being dragged to the "cundy" or "conduct," where the rope passes under the roadway. For branches, the rope will be led into different districts, connections being made at the flats. The hauling engine is a single cylinder on the second motion. A diagram showing the method of taking up the slack of the rope is shown in Fig. 39. Iron cross-sprags are used to place between the spokes of the skip wheels when there is so little room that the sprags must be pushed in a certain distance to prevent them from coming in contact with other objects; the guards are also useful when the skips are travelling fast, as there is then no danger of the boys pushing them too far in their haste.

A Brush motor, 450 volts, 15 amp., 1420 rev. per min., is used for working a pump, electric lights, and a corn cracker. The electric signals are worked by a battery, bare galvanised

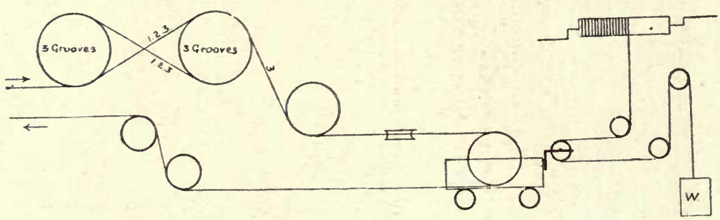


Fig. 39.—Method of Taking up Slack Rope.

iron wires being used so that they can be brought in contact when desired to signal anywhere along the roadway. Besides the two signal wires, there is a telephone wire and two pump cables. The button insulators are screwed to a piece of wood, which is nailed to wooden plugs driven into holes in the roof. The pump is a three-throw plunger, driven by a dynamo producing 350 volts, 13.2 amp., with 1230 r.p.m.

After passing through the screens, the slack is raised to a storage bin by a bucket elevator; it is then conveyed along a trough by scrapers, and is distributed to different parts of the bin by drawing a slide from a spout to let it down where required. This is worked by a rope from the haulage engine,

which is thrown in and out of gear as desired by a clutch. A tension pulley is used in connection with this rope. The stables (Fig. 40) is a brick building on the surface. That the animals are well cared for is proved by the fact that there is still one horse at work that has been hauling underground for 22 years, another for 17 years, and others for 13 years. The standard size for the horses is 14.3 hands. The animals come out of the mine every day, and at week-ends are put in a paddock. In the stable each horse has a stall to himself. Chaff is sent down a spout from the loft overhead into the manger of each stall, and there is a water trough in common

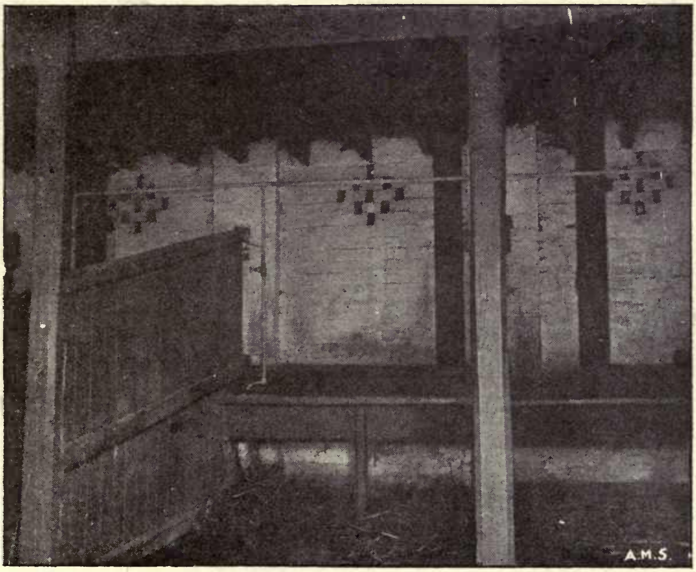


Fig. 40.—Stables.

between two stalls, which passes through the partition separating the horses. The troughs are supplied with water from a pipe arranged along the top of the stalls. The floor on which the horses stand is laid with wooden blocks, and slopes outwards towards a drain. The company grows its own green feed, but the chaff is bought. The corn cracker is worked by a $\frac{1}{2}$-h.p. motor.

This colliery also owns brick and pipe works, with the necessary crushing, grinding, mixing, and moulding machinery, and various kilns. Both common and fire bricks are

made from material obtained on the company's property. They use a patent Sercombe kiln, with eighteen chambers for brick burning.

The Hermitage Colliery.

This is one of the collieries of the Lithgow Valley Colliery Company, and is under the general management of Mr. J. Campbell. In many respects it is a duplicate of the Lithgow Valley Colliery. The colliery is worked from tunnels driven from the outcrop; the coal is extracted by the ordinary pillar and bord system, but the winning of pillars has not yet been

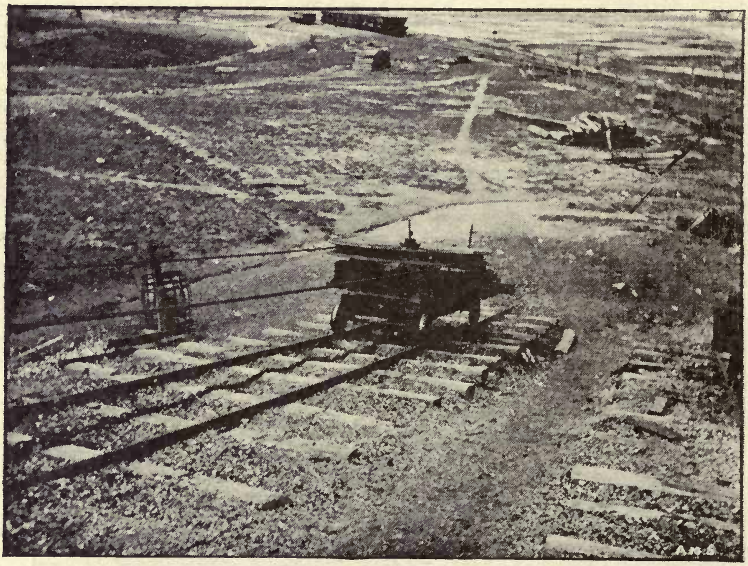


Fig. 41.—Tension Pulley.

commenced. The hauling is done by an endless rope, which rests in jockeys above the skips, but only one size of jockey is employed, for as no end gate is on the skip, a place is provided at either end for the jockey, which can be changed from one to the other according to which way the skip is travelling, so there is not the same fear of the skip tipping up when empty, as at the Lithgow Valley Colliery. The jockey consists of an iron rod, with a hook on the top at one side, for the endless rope to rest in. If this hook was in the centre of the end of a skip the rope might slip through it, but, being on one side, the rope, in its endeavour to keep a straight line,

causes the jockey to turn on its vertical axis, and in doing so the fork pinches the rope, thus gripping it firmly. The weight of the rope on the coal also adds slightly to the hold. The grip of a jockey is not strong enough for more than one skip at a time. The endless rope is not spliced, but has its sections connected together with 6in. sockets, the rope being swelled in the socket by driving a steel wedge in the core. The hauling engine was made at the Atlas Works, Sydney, and is a slide valve, link motion, geared 6 to 1. The grip wheel has one V-shaped groove. The tension pulley is mounted on a trolly (Fig. 41), and runs on a track down hill at an angle of 15 degrees.

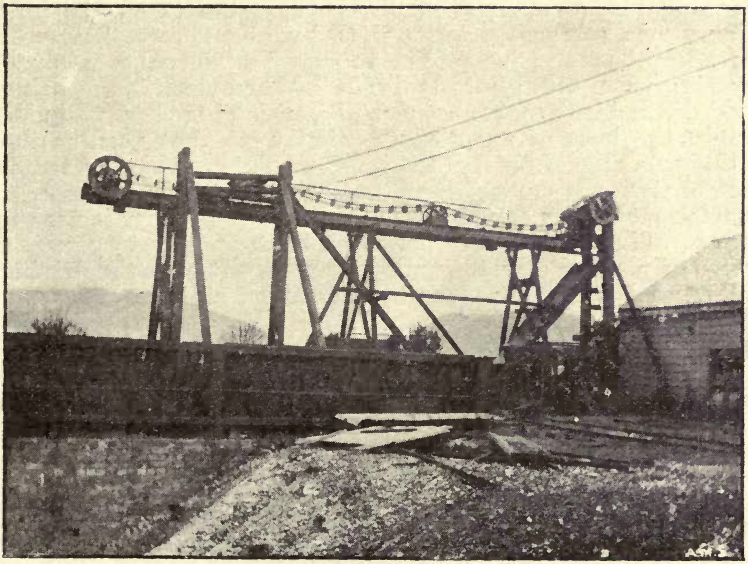


Fig. 42.—Conveyor.

Small doors are left in the stoppings now and again, so that repairing timber can be passed through to the return airways. Sliding doors are used for splitting the air. An Ingersoll-Sergeant air compressor, having one steam cylinder, 12 by 14in., and one air cylinder, which takes air in through the piston rod, is used for power to drive two pumps; one a Blake with a double ram—one at either end,—the other a Snow double-acting four-plunger pump. After passing over one of Pooley's weighing machines the skip is run into an end tippler, the hooks of which hold the skip by the two front wheels, not by the front axle; the band brake is worked by

foot. The screens are placed at an angle of 25deg., and are stationary. The bars, which are 1in. wide on top, half-an-inch wide at bottom, and 2in. deep, are arranged 1in. apart on the top, and as the space widens below, there is no fear of the coal clogging the bars. Also, the top of the bars, which are most subject to wear, is the strongest. As large lumps of coal might slide down quickly and carry slack with them before it has time to be screened, there are two or three rows of three knives, each weighted in such a manner at the end of a lever as to retard the rush of coal, though they eventually give way to the pressure, and as soon as the pressure is relieved, the weight on the lever brings the knives back into place again. When not required, these knives can be held back. The screens are 4ft. wide by about 15ft. long. A sheet iron brake is hung down to prevent the coal from overshooting when filling into D trucks. When slack is not being filled direct into trucks, a sheet of iron is rigged up to guide it into the boot of an elevator, similar to that used at the Lithgow Valley Colliery (Fig. 42). The slack elevator is worked from the endless rope, but as the latter only passes a quarter of the way round the pulley, in wet weather it used to slip, so filling pieces were bolted on to the pulley to give it a better grip. The elevator pulley is arranged above the driving pulley, and is put into gear by a common clutch.

Great Cobar Limited Colliery.

This is a small colliery worked by the Great Cobar Company in order to obtain coal for their own use. The whole 10ft. of the seam is extracted; any bands that can be picked out are placed on one side. Horses draw the skip to the flat, and as the road is high, big horses can be employed. An engine plane is used to haul the skip up the incline to the surface, and as the engine is located on one side of the incline, the rope has to pass round a diverting sheave to direct it down the roadway. The ventilation is carried out with the help of a furnace. The motive power for the pump is compressed air, used at 30lbs. per sq. in. The air compressor is one made by Horwood, of Bendigo. It has a single steam and a single air cylinder, and is provided with spring valves.

W. and J. Hoskin's Colliery.

This is another small colliery, which only works coal for use at the owner's local iron works. Being located between those collieries that can reach their seam by tunnels on the one hand, and those that have to sink shafts on the other, this colliery has a slope, which is worked as an engine plane, and is about a mile long from the suface. Six skips are brought in a set from the far end of the workings to the flat, and from

there a train of twelve skips is hauled up the incline. As the roadways are low, the horses for gathering the skips below cannot be more than 14.3 hands high. A furnace at the

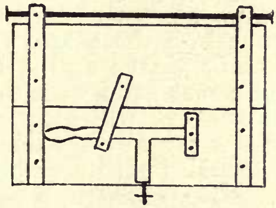


Fig. 43.—End Gate of Skip.

bottom of an air shaft serves to ventilate the mine. The skips have an end gate, which swings on an iron rod on the top, as shown in Fig. 43. It is only under exceptional circumstances, such as when coal has to be dumped in several places, that this style of skip is advisable, for a gate is always a weak point in a skip, while the first cost and subsequent repairs will soon more than pay for tipplers.

Vale of Clwydd Colliery.

This colliery has been under the management of Mr. T. Broughall for the past 18 or 19 years.

The coal has to be reached by shafts, of which, as usual, there are two, the downcast and upcast. The hoisting is done in the former, where a single truck cage is used, fitted with Hillman's safety catch (Fig. 44).

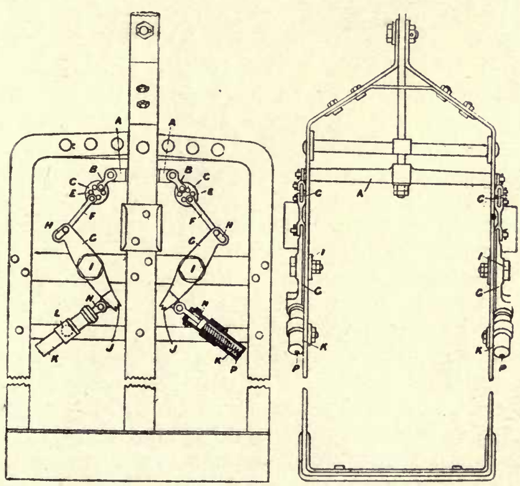


Fig. 44.—Hillman's Patent Safety Cage.

The main shaft is 243ft. deep, and is oblong in shape, being 12 by 6ft. in the clear. This is divided into three compartments—two for hoisting purposes, and one for pipes and hauling ropes. Side guides are used for the cages. A sliding gate, to protect the mouth of the shaft, projects a little into the shaft, so that it can be picked up by the top frame of the cage as it ascends and comes level with the brace. The cage rests on chairs at the surface, which are manipulated by the enginedriver, who pulls a lever at his side, which he rests in a notch when desired to pull the chairs out of the way so that the cage can descend. When released, a counterweight brings the chairs forward again. Skips are held in the cage by a balanced finger at both ends of an axle running with the longer axis of the skip. The bearings for this axle rest on cross-bars at either end of the cage above the skip. The weighted end of the finger rests on its cross-bar when the finger has to be raised. The winding engine is duplex, direct-acting, Tangye's M size. It has one drum, with two ropes.

Formerly the ventilation current was induced by a furnace, but now they have a double Champion fan, 8ft. in diameter and 4ft. wide. The top of the shaft is, of course, housed in, to prevent short circuiting of the air. This is an open fan, i.e., the foul air is expelled at the periphery, as in the case of the Waddle fan, so it requires no stack above it. This fan can be reversed without stopping it, by moving a wooden casing over the top when desired to blow down, instead of having the casing underneath, as is done when using it as an exhaust. The casing is turned by means of a sprocket wheel and chain. This fan is being used as an exhaust, and at present is given 200 revolutions per minute, but can be worked up to 300 revolutions. It is driven by a belt. In the fan-house is a steam capstan for lowering heavy weights down the air shaft.

The headings are arranged 60-80 yards apart, and the bords are driven off these to the rise. The bords are 4 yards or 8 yards wide, depending on whether they are worked by one or two men. The pillars are 22 yards apart from the centre to centre, thus making the pillars 14 to 18 yards wide, according to whether they are single or double bords. Pillars of 12 yards are also left between the ends of the bords and the headings. Air is brought up to the working face, as usual, by fastening brattice cloth to props with clout nails. Where necessary to divert the current in a working place, a drop sheet or curtain of brattice cloth is tacked on to a batten across the passage. This being made of two pieces, which slightly overlap in the centre, horses and men can easily find their way past, though the sheet forms a fairly good barrier to the passage of air.

The pillars are worked in eight-yard lifts, or strips taken off across them, commencing at the far end on that side of the

pillar where the other pillars remain standing; this protects the men as they work towards the broken ground. As work proceeds the roof is supported by props, with lids or cap-pieces. As successive lifts are taken off the pillar, the props, both in the far bord and the pillar, are knocked out with a hammer, to allow the roof to fall in, taking care always to keep 16 yards of roof supported between the miners and the

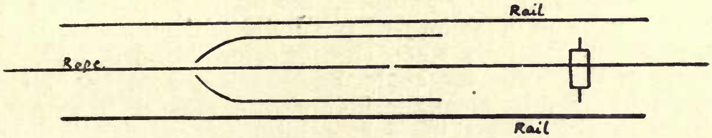
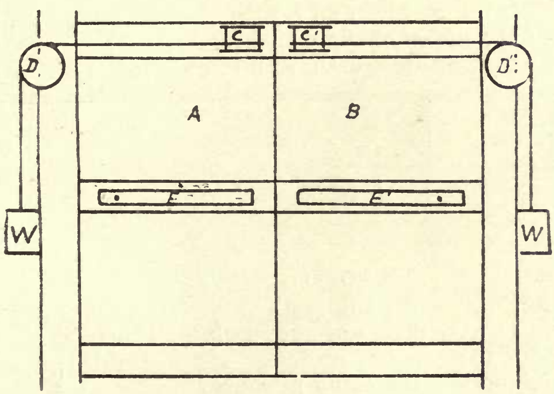
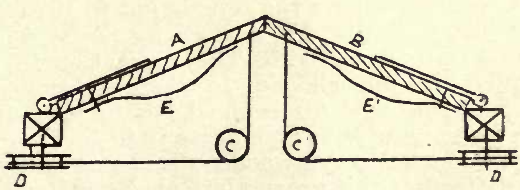


Fig. 45.—Diamond of L Iron.

fallen ground. The top coal comes down easily close to the props. The holing picks used are the standard double pointed 3½lb. tool. Sullivan's chain breast machines have now been introduced into this mine. In places the headings are supported by old bridge rails resting on old double-headed rails,



Elevation.



Plan.
Fig. 46.—Door.

well wedged against the roof. The former serves as the bar, the latter as legs.

The endless rope system of haulage is employed. One rope comes down the shaft and actuates two other ropes below, which are thrown in and out of gear by Fisher's friction clutches. The driving engine is a geared duplex engine of Tangye's make. The empty skips go down one roadway, while the full skips return by another. As the skips only travel one way, there is no occasion to have double diamonds for replacing skips on the rails when they become derailed. The diamonds in this mine are made, as shown in Fig. 45, of angle iron, held down by means of bolts strong enough to withstand a good shock. The skips open folding doors in the headings by pushing against them. These doors (Fig. 46), when closed, form an obtuse angle in favour of the direction in which the skip is going. A curved iron bar (E), fastened at one end and loose at the other, is attached to each door, and serves as a buffer for the skip to push against. This shape causes least friction, as the bar rubs against the sides of the skip. The doors are closed again by means of weights attached to cords passing over pulleys (D and C), the hinges being on the opposite side of the doors to the weights, or in some cases the doors are hung at an angle, so that they close of their own accord.

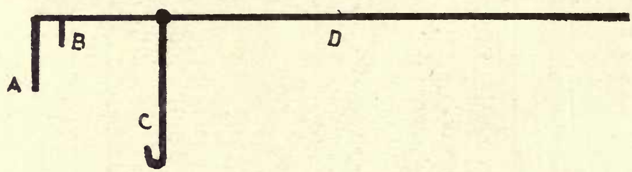


Fig. 47.—Shipper.

The tension pulley for the endless rope runs on an incline in a place where water does not accumulate. Instead of weighting the trolly of the tension pulley, a skip of old iron is attached to it, which serves the same purpose.

The track is laid with 18 and 20lb. rails, on ironbark sleepers 4ft. by 6in., placed 3ft. apart. Where curves occur, inclined rollers, called Tommy Dodds, are arranged, to guide the rope in the centre. Where the rope is apt to get off the rollers a shipper shown in Fig. 47, devised by the manager, is used to replace the rope easily. The projection (a) is inserted under a rail on the opposite side to where the rope is; (b) rests on the top of the rail; (c) is the hook to pick up the rope, which swings on a pin that connects it to the lever (d).

The greaser consists of a wooden disc between two iron discs of larger diameter; the groove left above the wooden disc is filled with rope. This retains the grease—that employed being provided by the Vacuum Oil Company—better than an iron sur-

face, it is therefore more suitable for slow haulage. The skips are made to ring a bell, which gives notice to the men that a set of skips is approaching the flat. The arrangement is shown in (Fig. 48), where (C) is a vertical iron rod that can

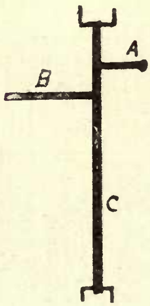


Fig. 48.—Signal Post.

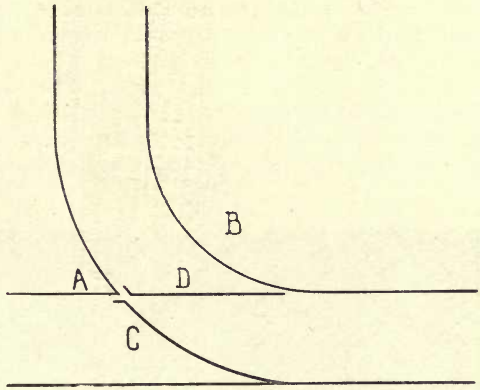


Fig. 49.—Geordie Turn-out.

turn in bearings at either end; (B) is a projection hit by the passing skip, and (A) is a lever attached to the bell wire.

As the full and empty skips all travel along the main roadway in the same direction on a single track, when a flat is reached from which cross-roadways branch to the workings off which it is desired to divert some of the empties, the selected skips are unclipped and switched into the cross-roadway, which has two sets of rails, one for the empties going in, the other for the full passing out. The latter return to the main roadway automatically when set free to do so, and are then clipped on to the main rope. Horses serve to collect the skips, and there are good stables for them underground.

Geordie turn-outs are used for turning skips into the several bords (Fig. 49). These are made of bar iron, square in cross-section, so as to be reversible when required for turns in opposite directions. The two rails forming the crossing (a) are welded together; (b) is known as the sweep-rail, (c) the sweep-point, and (d) the straight point. These square rails are fastened down with nails 4in. long by $\frac{3}{8}$in., provided with a chisel point, which pass through holes in the rail.

Water is raised from the goaf, where it collects, by a three-throw pump at the end of the main haulage. This is worked by the main rope passing over the top of the pulley that turns a chain, and sets the pump in motion. The main pump at the pit's bottom is one of Cameron's patent, made by Tangye, which is worked by steam.

There are three classes of weighing machines at this mine —Pooley's weighing machine, with a turn-table; a steelyard; and a Billy fair-play. The last is not now in use. It consisted of a large Salter's spring balance, connected by rods to a box made large enough to hold the slack from one skip. The bottom of the box is on an axle, which is placed a little on one side of the centre, so that it can be easily tipped up by means of a lever attached to the axle. The slack that falls through the screen collects in this box, and the weight can be read on the face of the dial of the spring balance. The bottom is then turned up, and the contents emptied into a railway truck.

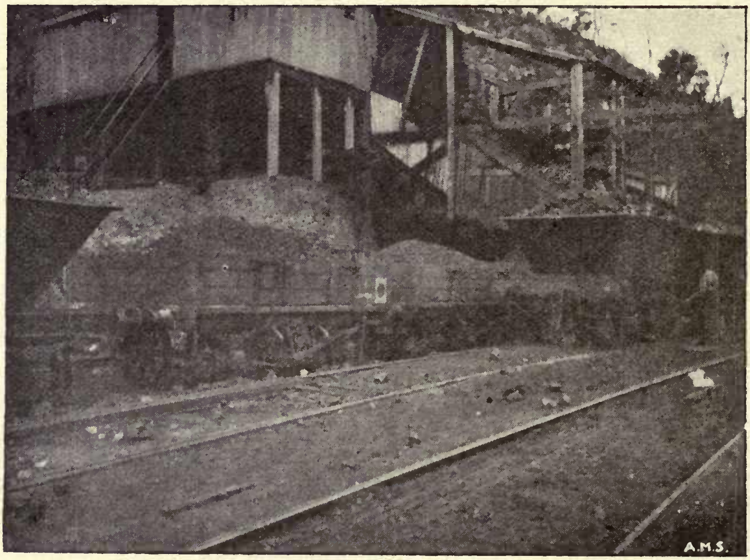


Fig. 50.—Screens and Waggons.

Hopper waggons are used for shipping coal, so that the bodies can be readily lifted out by cranes. But the D class of waggon is used for local consumption. To keep lump coal from sliding down the screens too quickly, and carrying slack with it, a series of so-called knives are placed between the bars, and, sticking up, retard the rush of coal (Fig. 50). These knives have their other ends weighted, and, when the pressure becomes too great, the knives are forced down so that the coal can get past; but the weight enables the knives to assume their erect position as soon as the pressure is relieved. The

steelyard is suspended from a strong beam (Fig. 51). The average tare of the skip is placed on the disc at the end of the steelyard. The jockey, or sliding poise, on the main beam, weighs up to 15cwt., while that on the auxiliary beam on the side is divided into quarters, and weighs up to 5cwt. The hooks (a) keep the frame, on which the skip is weighed, steady.

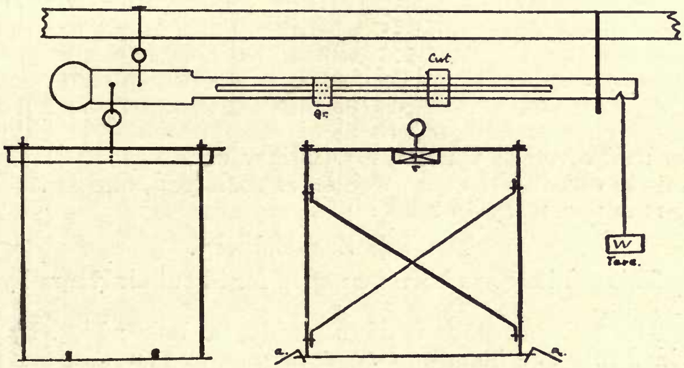


Fig. 51.—Steelyard.

In principle the steelyard is a lever with arms of unequal length, which rest on a fulcrum. In Fig. 52, (F) is the fulcrum; (FP) a graduated scale divided into equal parts; (p) is a sliding counterpoise; (A) a hook on the shorter arm, from which the thing to be weighed is suspended; (w) the pan for various weights. The parts that vary are the position of the counterpoise (p) and the weight on (W). The weight, multi-

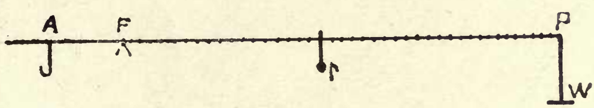


Fig. 52.

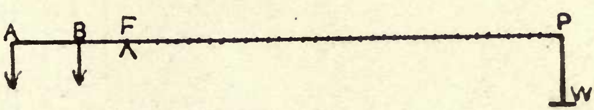


Fig. 53.

plied by its distance from the fulcrum, is equal to the resistance multiplied by its distance from the fulcrum. Thus $W \times PF = R \times AF$ where R equals the thing to be weighed.

This principle of the lever holds good, though there are more than two forces, as in Fig. 53, where $W \times PF = B \times BF + A \times AF$. The steelyard may have a supplemental arm attached parallel to the longer arm, which carries a second counterpoise. The mechanical effect of this is the same as if the second counterpoise were made to slide over the same arm as the first. The main bar carries the hundredweight poise, while the minor bar carries a slide which indicates quarters. The counterpoise must, of course, be in proportion to the class of weight used. When weighing with such a steelyard as shown in Fig. 51, the average tare of an empty skip is placed on the disc (w) at the end of the larger arm; the hundredweight counterpoise is placed at the minimum weight of a skip load of coal; while the auxiliary counterpoise is shifted about to obtain the exact weight of each load, and is the only one it is necessary to read off.

The Zig Zag Colliery.

This colliery has been managed for about six years by Mr. J. Durie.

The hoisting shaft is 210ft. in depth, being 14ft. by 7ft., divided into two hoisting compartments, and another compart-

Fig. 54.—The Travelling Road.

ment for pipes and ropes. The upcast shaft is 189ft. deep, and is surmounted by a brick stack 25ft. high. The brickwork goes down to solid rock another 25ft.

This shaft is 9ft. in diameter. The travelling road is an incline (Fig. 54) steps being cut in the rock to assist the men in descending. This travelling road, which is a hundred yards long, relieves the shaft, so that the engine has nothing to do but hoist coal and lower material. The record output for the downcast shaft from 6 a.m. to 5.30 p.m. is 678 tons. The hoisting engine is an old-fashioned single cylinder one, with a flywheel, built by John Cochrane, of Barrhead. The indicator is one of the vertical type, and a finger on it strikes a bell when nearing the end of a trip. The skips are kept on the cage by catches, which prevent the axles of a skip from going past them. A skip is run on the cage over one of these catches, the tail of which, being heavier than the head, causes the latter to rise up after the axle has passed it. At one side of the cage is a pedal, and by putting his foot on this, the banksman depresses the head of the catch, so that the front axle of the skip can pass over it; the front axle also depresses the head of the catch by means of a lever, thus keeping it down for the back axle to pass over.

Ventilation is induced by a furnace. It has no side flues, all the air passing over the fire. The furnace is 5ft. high, 8ft. wide, and 12ft. long. Its arch is 14in. thick, built up of headers set in loam, as this stands the fire better than lime mortar.

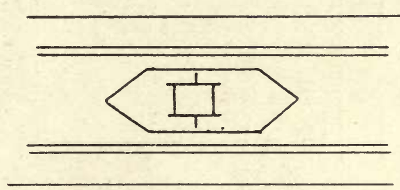


Fig. 55.—Diamond.

Steam is conveyed down the main shaft to a receiver, where any condensed water is separated, after which the steam passes to a two-drum duplex engine of Tangye's make, geared 2½ to 1. This drives the main and tail rope used for hauling purposes, which travels at the rate of seven miles an hour. The single line of rails has a gauge of 25in. Pulleys are bolted on to timbers at the side of the roadway to support the tail rope. The main tail rope is one mile twenty chains long, and the cap of the rope is connected to the skip by a shackle. There is only one branch line so far in connection with this

system, and that has a separate tail rope. A main rope has lasted five years. The old main ropes are utilised as tail ropes. At a junction, the rails are given a slight downward grade inbye, so that when the tail rope is unshackled the skip with but little help will pass over the points without the rope. There are 30 skips in a set, each averaging 19½cwt. of coal. At a curve, two bell sheaves are placed at either end, while drum sheaves are in the middle. The drum sheaves are 18in. in diameter, while the bell sheaves are 12in. in diameter at the bottom and 9in. diameter at the top. The object of the bell sheaves is to cause the rope to keep down, as it is well known that a circulating belt tends to climb the greater diameter. At curves, also, a rail is fastened to a board at the side, so as to keep the skips in an upright position. In case a truck should become derailed, a diamond (Fig. 55) is placed between the rails just before a curve, and an iron plate outside

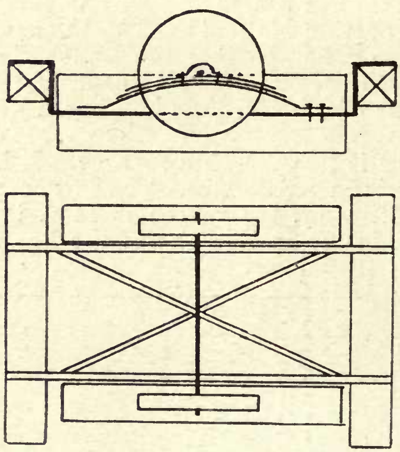


Fig. 56.—Greaser.

either rail, just opposite the diamond. The diamond is an iron-bound block of wood pointed at either end. If a skip in a set gets off the line, those on either side help to bring it more or less in position. The "kip" near the pit's bottom is about five chains long—two chains up and three chains down. It has a brick facing, capped with old railway sleepers, which are checked for the main sleepers to fit in. The incline is given a grade of 1 in 59. The greasers for lubricating the skip axles are smooth iron wheels mounted on carriage springs (Fig. 56). The lower part of these wheels dip into troughs of oil. As the axle of the skips come in contact with the

wheels of the greaser, the latter revolve slightly with the friction, while the spring, which is fixed at one end, but free to move at the other, exerts the necessary pressure. The spring is $1\frac{1}{2}$in, by $\frac{3}{8}$in., and the greaser wheels are 12in. in diameter. A pair of wheels are on one axle. The greaser wheels are smooth, and have not semi-circular pieces cut out of their periphery to fit the skip axles, for the latter require very little grease, and as these skips travel faster than they would in the case of an endless rope, the notches would pick up too much grease, and splash it about.

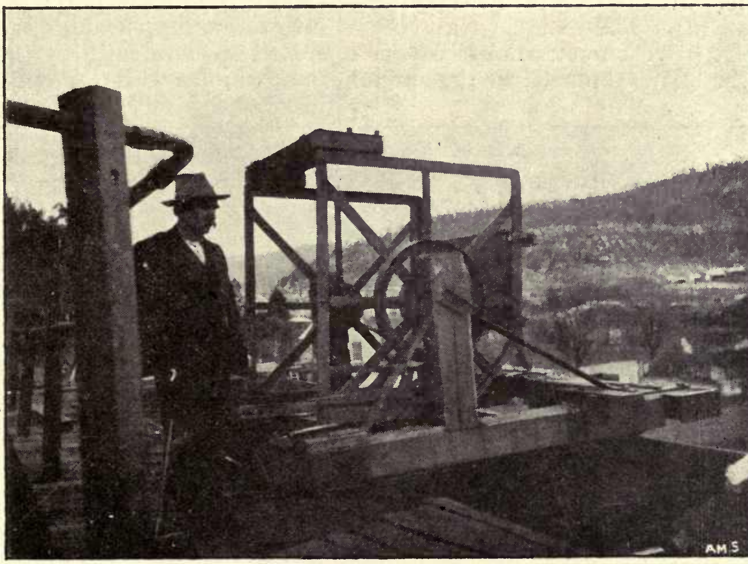


Fig. 57.—Travelling Tippler.

In the bords the usual bridge rails are used in lengths of 4ft. 6in. and 12ft. These are light, require no fishplates, and are fastened to the sleepers with plate nails. Horses 15.1 hands high draw the skips from the working places to the rope haulage. Naked lights are used, the lamp being the ordinary small coffee-pot type, carried on the front of the cap, against a piece of leather. In these Chinese oil is burnt, which is an oil made from the arachis or peanut. After weighing the skips they are run into a travelling tippler, which is an end tippler mounted on a trolly (Fig. 57), that can be run over a row of hoppers. The track is given a slight downward grade for the full lode, so that the force required to move it about equals that necessary to push the empty up again.

To drain the dip workings, an Evans' hydraulic pumping engine is used; while to raise the water to the surface, a Blake steam pump is located near the bottom of the main shaft. The construction of the hydraulic pumping engine can be seen by referring to Fig. 58. The motor cylinder (A) has two valves (B and C) above it; the piston rod (R) is a continuation of the rod of the plunger. The water for motive purposes first enters the chest of the auxiliary valve (B), from which it passes through a port into the chest of the valve (C). There is also a communication with the main valve chamber (J), from which the water passes into the cylinder (A), through the ports (b) and (c). The exhaust water flows into the sump through the port (d). The auxiliary valve is operated mechanically by the arm (L), attached to the piston rod, which, while moving

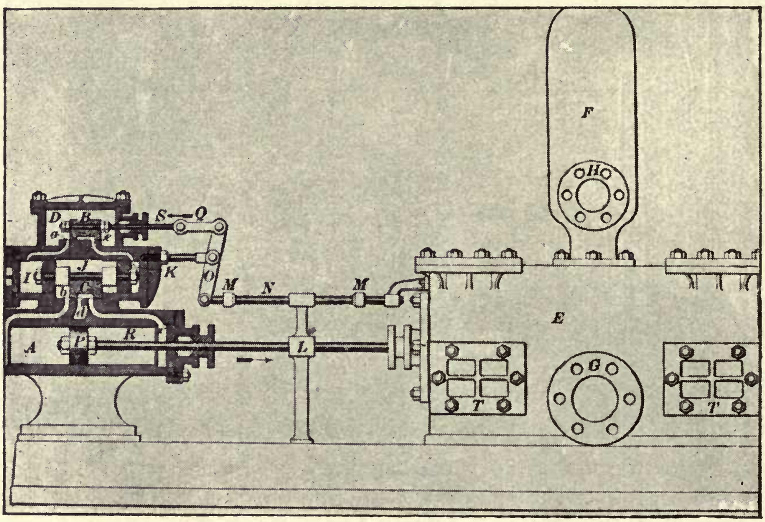


Fig. 58.—Evans' Hydraulic Pumping Engine.

alternately backwards and forwards, strikes in turn the lugs (M.M.) attached to the rod (N) that actuates the rocker (O), connected with the far end of which is the link (Q), attached to the valve stem (S). A small quantity of water under pressure due to head is thus enabled to lift a larger quantity of water a lesser height. The motive water presses equally on either side of the valve (B), which, being moved mechanically first on one side and then on the other, allows the water to pass alternately down the ports (a and e) to the valve chest (C), and from the latter to the water exhaust pipe. The area

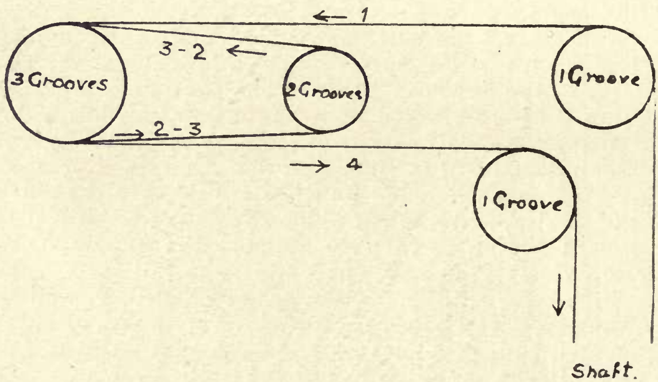
of the motor piston is smaller than that of the pump piston. The controlling valves of the motor cylinder are made of lignum vitae, as this wood is sufficiently lubricated by the water. The pump will work without the auxiliary or jockey valve, but in that case must move faster. The auxiliary valve makes a dead centre almost an impossibility, so with it the pump can work very slowly—so slowly that it can scarcely be seen to move.

Oakey Park Colliery.

This colliery belongs to the Oakey Park Coal Mining and Coke Company Limited, and has been managed by Mr. Robert Hay for about sixteen years. The coal seam is reached by means of two shafts. The downcast is used for hoisting both men and coal, while the upcast is used solely for ventilation purposes, the ventilation being carried out by means of a furnace with side flues, and exhaust steam from the pumping engine. Eventually a fan will be installed, and the upcast shaft will be used for travelling purposes, so as to increase the hoisting capacity of the downcast shaft. The shafts are circular in cross-section, and are bricked up near the top, but lower down the natural rock stands fairly well, though no doubt it would save trouble in the future if the shaft had been lined originally from top to bottom. Wooden buntons are let into the sides to support the guides, and a heavy oblong frame of wood is placed on the top of the brickwork to support the superstructure. The cage only carries one skip at a time, the full skip pushing the empty one out at the bottom when changing, and vice versa at the top. The cages are provided with safety catches of the serrated cam type; levers from the cam axles are connected by chains to the draw-bar of the cage, by which means the cams are kept off the guides. A spring attached to each cam draws them together when the draw-bar is released. The cages have shoes both on ends and sides. The end guides are used when travelling through the shaft, for, being arranged on the narrower sides, the cage has less play than if the cages were guided from the longer sides, as is usual; but as these end guides would be in the way of caging and uncaging the skips, provision has to be made for changing to side guides near the top and bottom of the shaft. About five feet below the collar of the shaft side guides are fixed, and are continued up the head frame. The ends of both end and side guides, where the shoes first engage them, are bevelled off, so that the shoes can embrace them easily, and as the cage slows down at the end of a trip, there is no difficulty in changing from one pair of guides to the other. The axles of the safety catches, which are arranged for the end guides, pick up a light iron sliding gate as the cage reaches the surface, and on descending leaves it behind to protect the mouth of the shaft.

The main haulage roadway is the intake, while the travelling road is the return airway. The main haulage has been properly graded, and is straight except where proximity to a neighbouring property necessitates a curve. Track laying is a very important matter in the economy of a mine, and when properly done will pay for itself many times over by saving useless wear and tear of plant and expenditure of unnecessary power.

The coal won is about 5½ft. of the middle coal, which is fairly free from bands; the bottom coal is 12 to 15in., and the top coal about 4ft., which is inferior, and interbedded with bands. The ordinary bord and pillar system of working is used to win the coal. The bords are of two widths, being four yards for a single man and eight yards wide for two men; they are driven 60 to 80 yards long on either side of a heading, no



Elevation.
Fig. 59.—Rope at Top of Shaft.

matter whether to the rise or dip. The pillars are about 25 yards wide. The neck of a four-yard bord is opened out to its full width right away, but that of an eight-yard bord is commenced four yards wide for four or five yards, after which it gradually widens out on either side till a width of eight yards is attained.

The system of haulage employed is the endless rope, which is set in motion by an old P. N. Russell and Co.'s engine, working on the second motion; but this engine will shortly be removed to another part, and be replaced by a more powerful one, which is now on the ground, this being necessary in order to cope with the greater amount of work to be done. The main haulage rope is ⅞in. diameter, and has a circulating length of 2400 yards. It travels at the rate of two miles an hour, and four skips are clipped on at a time to make a set. The district ropes are ¾-in. diameter; they travel at the rate of

one mile per hour, so as not to crowd the main flat or junction, and they only take two skips in a set. The No. 1 or eastern district rope has a circulating length of 1300 yards, while the No. 3 or western district has a total

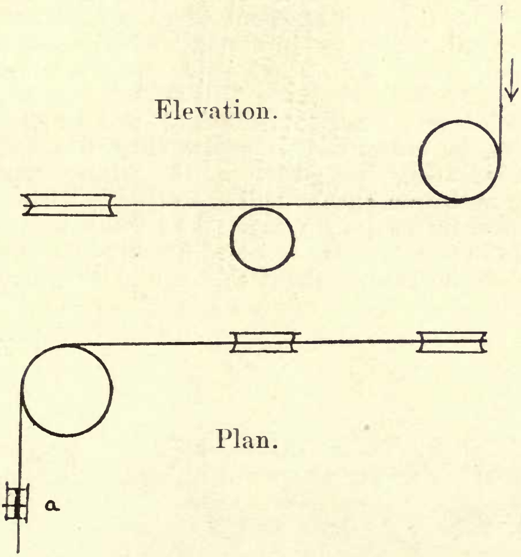
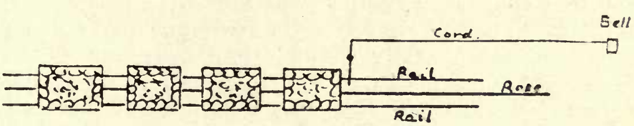


Fig. 60.—Rope at Bottom of Shaft.

length of 2700 yards. Screw dog-clips are used to fasten a set to the rope, while coupling chains, made of three long links, connect the different skips. Fig. 59 shows how the main rope circulates at the surface between the engine and top of the shaft, while Fig. 60 shows how the rope is guided in the direction required at the bottom of the shaft. The small idler (a) is made out of two old skip wheels bolted together, as shown.



Plan.
Fig. 61.—Automatic Signalling.

Where the curve occurs on the main haulage-way, centre sheaves, or "Tommy Dodds," are used to keep the rope in the middle of the track; these sheaves are placed vertically, and rotate on a bolt fastened to a sleeper. A long-handled hook is

kept near this curve, in case the rope should get off the sheaves and require to be lifted on again. When the skips approach this curve they are caused to go up a slight incline, so that when the curve is reached they can run down by gravity without requiring any pull from the rope to which they are fastened. With this arrangement there is no occasion to tilt up the inner rail, which would otherwise be necessary to counteract the pull of the rope, which tends to go in a straight line. When skips approach the pit's bottom, at a given spot each one strikes a lever, which pulls a cord, and rings a cow bell, so as to give the putter-on due notice (Fig. 61). The greaser used for lubricating the axles of the skips consists of a rubber disc with iron cheeks bolted to it. No springs are used as with the ordinary iron greaser, and when the rubber gets worn down the bearings are raised. The skips travelling slowly do not knock the rubber about so much as to wear it unduly.

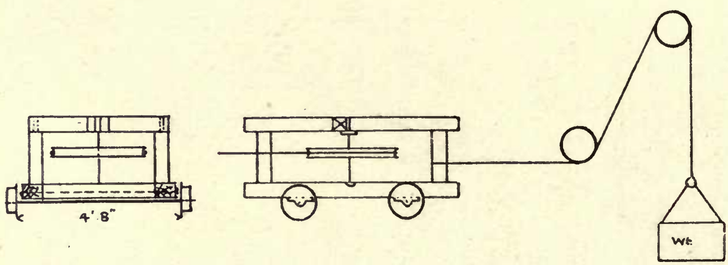


Fig. 62.—Tension Pulley.

The district ropes are worked from the main rope, but the speed is reduced by gearing from 2 to 1. Each district is thrown in and out of gear by a common claw clutch. Working one shift a day, a district rope lasts about four years. The tension pulley is mounted horizontally on a trolly, which runs up and down on a side track, being kept taut by a box of old iron (Fig. 62). At flats the curved rails are made of 1½in. square steel; these are more easily shaped than ordinary "T" rails, and they serve for curves to either right or left by simply reversing them. The rail that crosses the track of the rope has a groove cut through it, so that the rope can circulate without undue wear and tear. As shown in Fig. 63, the turn-off on the full track is provided with an automatic tongue switch, worked by a weight. The branch from the empty main track crosses over the full main track, and when in use portable loose rails are placed over the latter to make the connection, the loose rails being kept in place by dog spikes on the outside of rails only.

Horses are sent below in a horse-box, provided with double doors at either end. The small upper door opens sideways, but the lower door has its hinges on the bottom, so that it can open downwards and serves as a stage for horses to walk over.

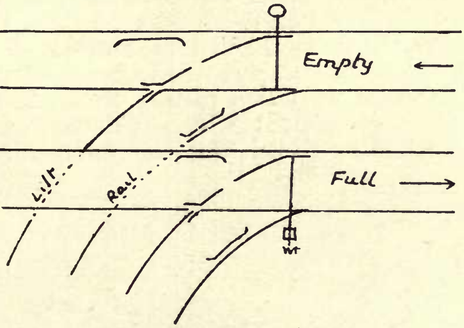
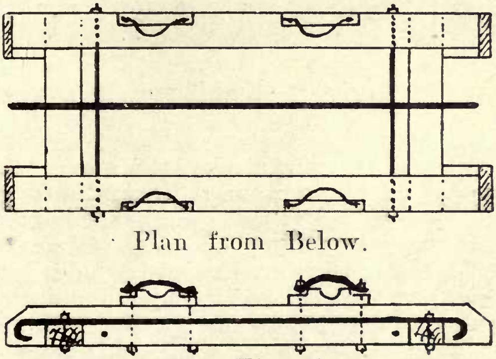


Fig. 63.—Crossing.

The box has shoes to engage the guides in the shafts, and it is suspended from the bottom of the cage by a ring attached to the top of the horse-box, which passes through a hole cut for it in the floor of the cage. This is secured by passing a bar through the ring so that it can rest on the rails in the cage.

The skips are built up on a rectangular wooden framework (Fig. 64), underneath which a draw-bar is bolted, which has a hook at either end. As all the pull is on the draw-bar, the wooden structure is not strained. The skip wheels are kept in their bearings by round iron bolted into position, which is bent inward, so that the greasers can lubricate the axle opposite the bearings. The bottom of the skip is made up of four planks, the sides and ends being made of two



Plan from Below.

Side Elevation.

Fig. 64.—Undercarriage of Skip.

planks, which are 14in. wide and 1in. thick. These planks are bolted to angle iron at the corners, and are strapped with iron on the sides; a rim of iron is fastened all round the outside edge. The skips are weighed on one of Henry Pooley and Sons' platform machines. When weighed, the skips are run into an end tippler, the hooks of which catch the front axle of the skip as the coal is tipped on to the screens (Fig. 65).

Water is raised from the dip workings by a pair of rams worked from the return sheave of the main haulage by gearing, which increases the speed from 1 to 2. These force the water to a water level, along which it flows to old workings, which form a lodgment; from this it is pumped to the surface

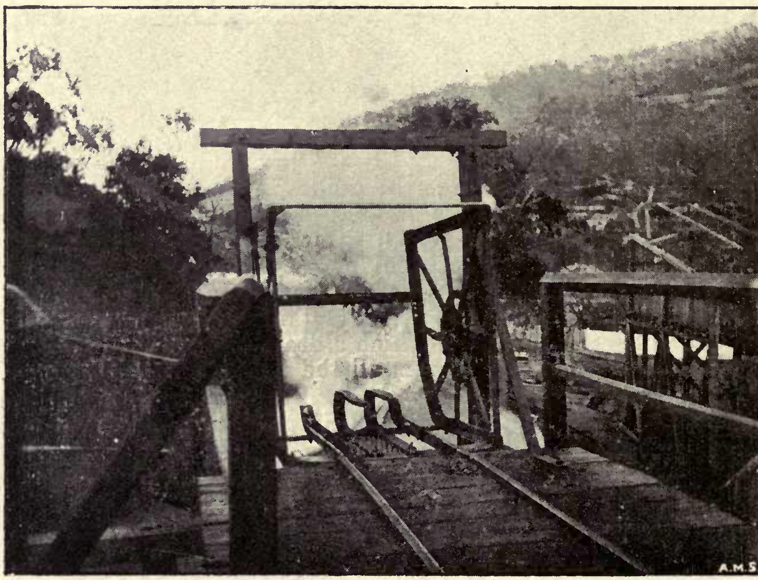


Fig. 65.—End Tippler.

by the Tangye pumps. There are two Tangye pumps, one with an 8in. plunger and 3ft. 8in. stroke, the other, which is held in reserve, has a 6in. plunger and a 3ft. 2in. stroke.

The coal is classed as forked, slack, and shandy or shovel-filled. This is the only colliery in the Western coalfield that makes coke. Coke is more expensive to make here than on the South Coast, as the coal is harder to break up, requiring about 40 per cent. more crushing power, and it has to be washed to reduce the quantity of ash, which causes a loss, besides which the moisture has to be driven off, which takes time and heat. The coke is good, and it is all consumed by W. & J. Hoskins at the ironworks. To help equalise this extra

cost of making coke, the coal is cheaper to mine than on the South Coast. The roof is good, whether it consists of top coal or sandstone, and requires scarcely any timber, thus saving the cost of timber and time in setting up. The workable coal is a suitable height to extract, and, as the mines are not gassy, the men can work with naked lamps, which give a better light than safety lamps. The fine coal used for coking is hauled up an incline in a skip, which has a sliding door at the lower end. To this door is attached a pair of wheels which, when the skip arrives near the end of its journey, runs on a short steeper incline outside the rails on which the skip proper runs (Fig

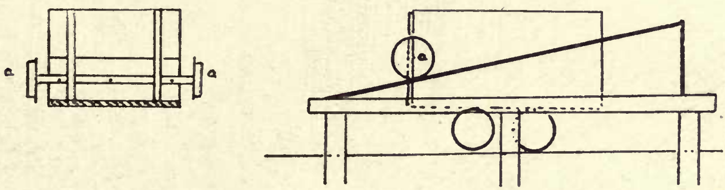


Fig. 66.—Automatic Discharging Skip.

66). This causes the door to slide up when over the Carr's disintegrator. The disintegrator breaks up the coal to a suitable size for coking, and by doing so the beaters, which were originally circular in cross-section, wear to a triangular shape. The powdered coal falls into one of a pair of sluices; one sluice is cleaned up while the other is in use. The dirt collects in the upper portion of the sluice, while the coarser coal, with a small amount of dirt on the top, settles a little lower down, and the finer washed coal occupies the lower section. The sluice has an occasional riffle bar placed across it. A tram line runs alongside the sluices, and the dirt is dug out or skimmed off the top into skips, and run over the tip. The coal is sluiced down into a washed-coal hopper to settle. There are four of these hoppers, which have a capacity of about 27 tons each, and each hopper has a separate branch from the sluice to itself. These hoppers are V-shaped, and the water drains off from the coal while in them. When fairly dry the coal is drawn off through slide-gates into canisters, which convey it to the top of the ovens. By washing the coal they get rid of about 10 per cent. of dirt. There are 32 old style of beehive ovens, in which the needles of coke spring from the floor. Black ends, which consist of improperly coked coal, are mostly found at the bottom. Very little ash from burnt coke is found on the top of a charge. There are also 40 improved type of beehive oven, of an estimated capacity of 10 tons each per week, built so that the finished product can be pushed out by a ram. The walls are built of good local machine-made common bricks, and the roof of Lithgow Valley shaped fire bricks. The ironwork for these were made by William Davies, of Wollongong.

Irondale Colliery.

This colliery belongs to Messrs. J. B. North and Sons, and for three years has been under the management of Mr. J. Fitzgerald. It is situated a few miles from Wallara-

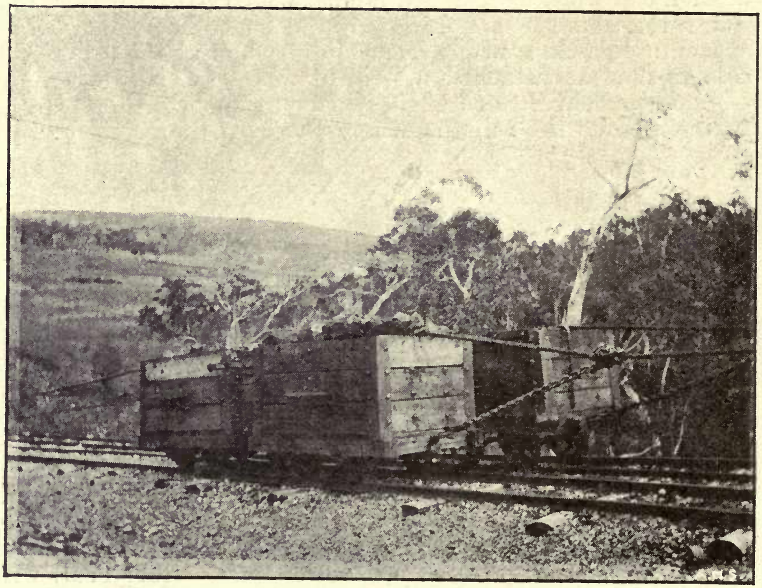


Fig. 67.—Lowering Skip with Jockey and Tail Chain.

wang. Two seams are worked—the dull seam, which is supposed to be a continuation of the Lithgow seam, and varies from five or six feet to over seven feet in thickness, but averages about six feet; and the bright seam, about 75ft. lower down the hill, which is 4ft. thick. The latter is the better coal, but this is the only place where it is free enough from bands to be worth working. The coal sticks to the roof, but it is too jointy to blast. The roof, which is sandstone, is good; the floor is grey shale. The floor of the bright seam has to be lifted to make headroom in the roadways. This is done by drilling holes about 3ft. deep with a ratchet and auger and charging with powder. Thin bands of carbonate of iron, more or less contaminated with clay, occur in the shales near these coal seams. These are locally called "clay bands," and where exposed to the air become oxidised. On other land in this district, belonging to the same owners, both ironstone and limestone are found. The seams are worked from tunnels, and the coal is lowered down the hill in skips on a gravity plane, consisting of a double line of rails provided with an endless

rope. The speed is regulated by a brake at the top. The incline for the upper seam has an angle of 14 degrees. The

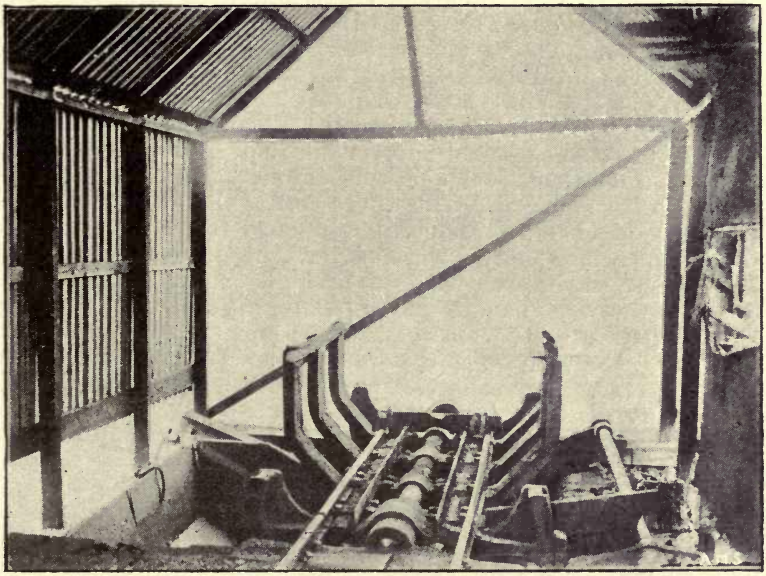


Fig. 68.—Side Tippler.

skips have a jockey in front and a chain behind (Fig. 67). The jockey alone would cause the down going skip to tip up, so that it would run on the two front wheels only, therefore the back is kept down by means of a 7ft. close-linked chain, which has a hook at either end. One end is wrapped round the rope about four times; then the hook, being close to the rope and pointing down hill, is turned on its back, so that the longer piece of chain can be hitched into it; the hook at the other end of the chain is fastened to the back of the skip. One or two skips may be sent down at a time. Should a skip accidentally get away and break the chain of that in front, the jockey will cause it to tip over and block any further accident. The skips are weighed on a W. and T. Avery's weighing-machine. A side tippler is used to empty the skips (Fig. 68). The skips are not held in position by the wheels or axles, for should these become loose the skip might fall out at the top; but angle iron is bolted on to the sides of the skips, which catch in the side angles of the tippler. A wooden block at the end of the tippler prevents the skip from going too far, as it has to be drawn back, and is not pushed forward. The tippler is eased down by a screw brake, which works in a path of a half-circle at either end.

The Ivanhoe Colliery.

This colliery, which has been under the management of Mr. W. Burns for three years, belongs to the Commonwealth Portland Cement Company, who took it over in 1902. The coal extracted is used at the company's works. A little work has been done on the upper seam, but it is not being continued. The "dull seam" is the one worked, and this is from 6ft. 6in. to 7ft. 9in. thick. The roof, which stands well, is sandstone, while the floor is shale. There is a persistent band in the coal about 10in. from the roof. The lower coal is first holed, broken down, and filled into skips; then the band is taken down, and finally the upper coal. By this means the coal is kept clean. The coal is a good steaming coal, and burns to a white ash. Two men work in an eight yard bord. The roadway is brought up in the middle of each bord, so that one man can work on one side of it, and his mate on the other. Two skips are at the face at a time; one for each man, and they take it in turn to fill the front one. The skips are drawn out to the surface by horses, and then sent down an incline connecting the tunnel with the coal hoppers. The skips on the self-acting incline are attached to a circulating endless rope by a short linked chain. The speed is regulated by a brake at the top of the incline. The skips have an end gate and their contents are discharged into the hoppers by means of an end tippler. The front end of the tippler is one foot from its axle, while the rear end is two feet; when full the skip tips over, and when empty the counter weight helps it to right itself again. There are four hoppers, arranged in two pairs, so that four railway trucks—two on each set of rails—can be filled at a time. There is a spout at the bottom of each hopper which is closed by a curved door, worked by means of a lever, which can be padlocked in position, if desired, by passing a pin through an iron bar and the lever handle, and placing a padlock through a slot left for that purpose in the pin.

The mine is dry, so there is no pumping to be carried out. The ventilation is done by means of furnaces.

Cullen Bullen Colliery.

The original colliery of this name, which was the second oldest colliery in the Valley, was purchased by the Lithgow Coal Association and dismantled. A syndicate has secured a few acres, which are being opened up, and a small trade is being done with the coal won. At first the coal had to be carted to the railway, preparatory to a horse tram being laid down.

The Portland Colliery.

This is a small concern, the coal being carted for local consumption only.

CHAPTER XIV.

The Southern Coalfield, N.S.W.

The Southern Coal Field is in great contrast to most coal fields so far as scenery is concerned. The surface works of the various collieries are located in the scrub belt, rich in palms, creepers, ferns, and other vegetable life. When walking along a bush track where the trees meet overhead, and an occasional glimpse of the South Pacific Ocean is caught in the near distance, coal mining, with its accompanying noise and dirt, is one of the last things to enter one's mind. Yet it is going on underfoot all the time.

Some idea of the dip of the coal basin may be obtained by observing the level of the outcrop above the sea along the South Coast. At Mount Kembla, which is the furthest south productive colliery, the tunnels are about 800 feet above sea level; at Mount Kiera they are about 715 feet; at Mount Pleasant, 548; at Corrimal, 498; on reaching North Bulli (Coledale) the outcrop is 300 feet above the sea; at South Clifton (Scarborough) the seam is found outcropping 166 feet above the sea, but although the travelling road has its entrance on the face of the cliff, the coal is raised from shafts in order to gain height, as the coal is sent away by rail. At Coal Cliff the seams crop out at sea level, while at the Metropolitan Colliery (Helensburgh) nine miles further north, it is 1100 feet deep. The Sydney Harbour colliery, the deepest in the State, reached coal at 2880 feet.

Of the five workable seams in the Illawarra series, operations have only been carried on in three. The Upper, or Bulli seam, is the main one, which is being worked by all the collieries. The four-foot seam has been worked to a limited extent at the Mount Pleasant and Bulli collieries, and a bed of kerosene shale was worked some years ago at the base of Mount Kembla.

The following data relating to boreholes sunk for coal are of interest:—*

Locality.	Height above sea. Ft.	Total Depth. Ft.	Date.	Remarks.
Camp Creek (Helensburgh)	336	—	1884	Struck 12ft. coal at 846ft.
Heathcote (near Waterfall)	467½	1586	1886	1st seam 4ft. 8½in., struck at 1513ft. 2nd seam 6ft. 1in., met with at 1577ft.
Holt Sutherland No. 3 (Dent's Creek)	132	2307	1887	1st seam 4ft. 2in., at 2228ft. 2nd seam 5ft. 3in., at 2296½ft.
Moorebank Estate (Liverpool)	40	2601½	1890	1st seam 1ft. 5in., at 2493½ft. 2nd seam 1ft. 4in., at 2507ft. 7in. 3rd seam 6ft. 6½in., at 2583ft. 4in.
1st Robertson's Point (Cremorne)	54	3005	1890	Coal 7ft. 3½in. cut at 2801ft. 9in.
2nd Roberston's Point (Cremorne)	ft. in. 139 7½	2929	1892	Coal 10ft. 3in. at 2917ft.

Other boreholes that were not sunk deep enough, and were abandoned for several reasons, are as follows:—

Locality.	Total depth. Feet	Date.
Newington (Parramatta River)	1312	1878
Holt-Sutherland No. 1 (Botany)	2193	1879
Moore Park	1860	1880
Narrabeen	1985	1883
Cooper Estate (Rose Bay)	1700	1888

*T. W. E. David and E. F. Pittman, "Notes on the Cremorne Bore (Trans. Roy. Soc., N.S.W., 1893-4).

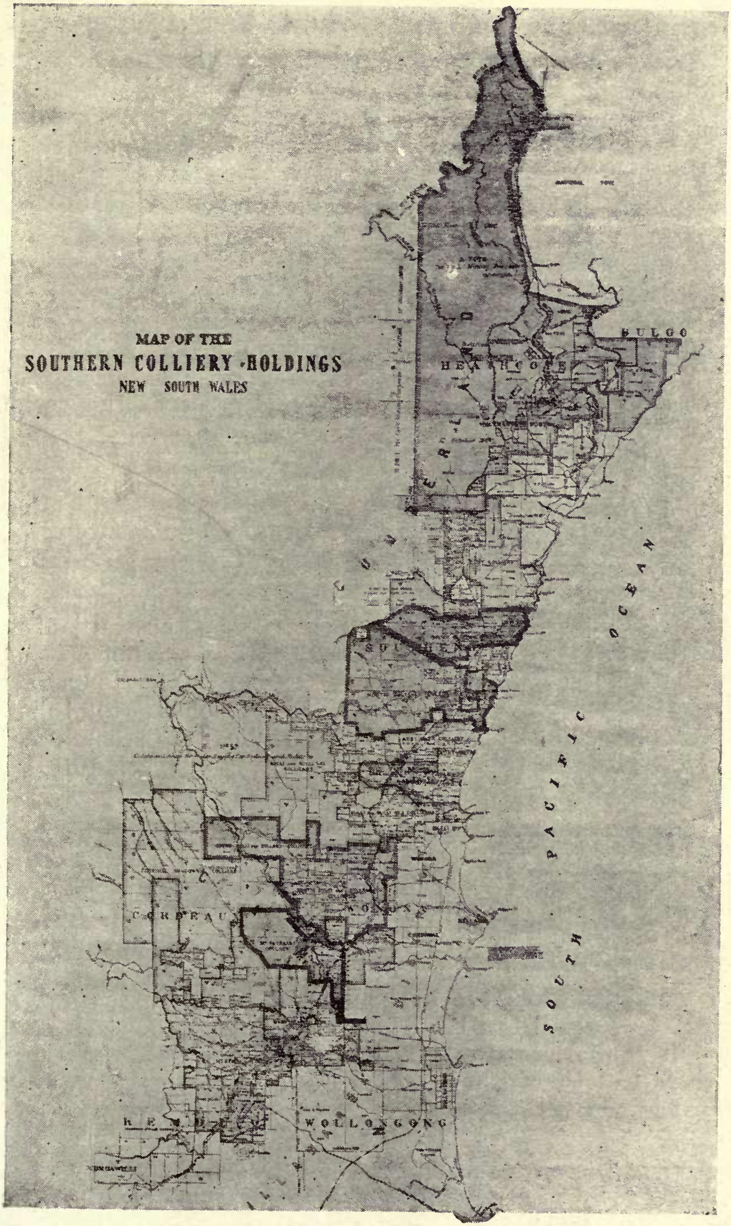


Fig. 69.—Southern Coalfield.

In the Southern Coal Field there are two explosive gases recognised, known as the top and bottom gases. The former is ordinary fire damp. The latter collects in hollows, and can be dammed back like water. Its composition has not yet been properly investigated, but one analysis of a sample taken from the Metropolitan colliery, made by Mr. W. M. Hamlet, returned

8.35 per cent. by volume of CO.
14.31 per cent. by volume of CO_2
14.50 per cent. by volume of O.
trace per cent. by volume of H.
7.64 per cent. by volume of CH_4
55.20 per cent. by volume of N.

A map of the Southern Coal Field is given in Fig. 69, which shows the relative positions and areas of the various collieries.

The Sydney Harbour Colliery.

This property, comprising an area of 10,167 acres, underlies the Sydney Harbour, and belongs to an English-Australian Company, known as the Sydney Harbour Collieries Limited. The company holds a concession from the Crown at a low annual rental, which will eventually merge into a royalty of sixpence per ton on large coal, and threepence per ton on small coal. Two boreholes were sunk at Cremorne, on the North Shore side of the harbour. The first, in 1890, reached a total depth of 3005 feet, but struck coal at 2801ft. 9in.; the second, sunk in 1892, reached a total depth of 2929ft., and struck 10ft. 3in. of good coal at 2917ft.

A site was secured for the surface works having a water frontage at Long Cove, Balmain, and work commenced eight or nine years ago, under the supervision of Mr. J. L. C. Rae, was continued by Mr. B. Sokehill, and is now under the management of Mr. W. E. Lishman.* The freehold is bounded by two streets and a water frontage of 580ft., and, together with the land reclaimed from the harbour, has an area of nearly five acres. A sea wall has been built, the finished level of which is nine feet above low water. The depth of water off this wall, which is less than a hundred yards from the pit's mouth, is 26ft. at low tide.

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*Since the above was written, this colliery has changed hands, and is now under the management of Mr. A. K. Broadhead.

There are two shafts placed 168ft. apart from centre to centre, their mouths being 80ft. above low water mark. The ground round about has been levelled off and supported by strong rubble retaining walls. The Birthday shaft, 2935½ft. deep, was the first to be sunk, this being let on contract to Mr. T. Cater. It is the main winding and downcast shaft. The Jubilee shaft, 2950½ft. deep, is the upcast, but will also be used for winding, if necessary.

Considerable disappointment was felt when coal was struck in the Birthday shaft, for the seam at this point was found to be split up. The upper seam, which was met with at 2880ft. from the surface, consisted of :—

2ft. 4in. bituminous and splint coal.
3ft. to 3ft. 2in. very dark, jointy, carbonaceous coal.
2in. inferior splint coal.
6in. to 8in. bituminous and splint coal.

This dipped 1 in 40, bearing N. 75deg. E.

The middle seam came in 29ft. 11in. lower, and consisted of 1ft. 8in. bituminous coal, dipping 1 in 17, and bearing N. 47deg. E. The lower seam was met with at a further depth of 15ft. 10in., or 2933ft. 7in. from the surface. This comprised:

3in. black shale.
3in. cannel coal.
8in. carbonaceous clay shale, and thin layers of bituminous coal.

The dip was 1 in 11, and the bearing N. 13deg. E. A borehole sunk from the bottom of the shaft passed through a 9in. thick band of splint coal at a depth of 2990ft. 3½in., and a bed of bituminous coal about a foot thick, at a depth of 3007ft.

The sinking was started with two steam cranes, one of 5 tons, the other of 7 tons capacity. The jibs acted as headgear over the shafts, and enabled the material obtained from the sinking to be easily spread around the shaft, thereby assisting in levelling the ground and saving time in waiting till the hoisting machinery could be erected. These cranes gave satisfaction, though the speed of winding was rather slow, but the depth for which they could be employed was limited by the length of rope that could be coiled on the barrel in a single lap. In the Jubilee shaft a depth of 125ft., that is from 29ft. below the surface to 154ft., was sunk through hard sandstone by this means during four weeks. At a depth of 71ft. in the Birthday shaft a tunnel has been turned off towards the quay wall, the idea being that all heavy stores, such as pit timber and rails, could be run in from the quay direct. This tunnel is 14ft. by 12ft. in the clear at the shaft, and is then reduced to 8ft. by 10ft., but has not been completed. Both shafts are 18ft. in diameter, and there is a pillar of solid ground left round them, having a radius of 375 yards.

For some of the following figures I am indebted to a paper on "The Deep Sinking of Shafts at Sydney Harbour Colliery," read by Mr. J. L. C. Rae before the Engineering Association of N.S.W. on 15th October, 1900. A temporary sinking engine was erected at each of the shafts, which is placed so close to the shaft that there is room behind for the permanent engine to be erected. The Birthday shaft engine consists of a pair of horizontal, coupled, direct-acting, high-pressure winding engines with 28in. diameter cylinders, and 5ft. stroke. It is provided with Cornish equilibrium valve gear.

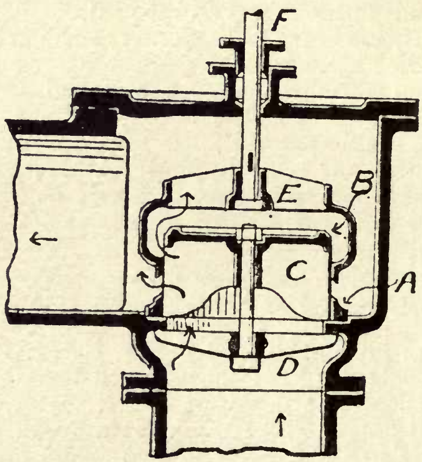


Fig. 70.—Cornish Valve.

link motion reversing gear, steam valves 8in. in diameter, exhaust valves 9in. in diameter, and Cornish equilibrium throttle valve. There is only one winding drum, which is 14ft. in diameter, by 5ft. 6in. wide, with a splash board to prevent the dressing from being thrown off the rope about the engine room; it is provided with two brake flanges, one on either side: these were originally rough, and fitted with wooden blocks, on which a wrought iron brake strap, operated by the enginedriver's foot, worked half-way round the circumference. This was subsequently altered, the flanges being turned while in their present position, and fitted with brake blocks on long levers of the Burns type, and the leverage increased, it now being 64 to 1. An auxiliary drum was keyed on to the crank shafting inside the main drum while sinking, on which that part of the sinking rope not actually in use for the time being was coiled. As sinking proceeded, this rope was paid out by

drawing the keys of the internal drum, and turning it by hand. The section of a Cornish double-beat valve, with the valve raised, is shown in Fig. 70: the lower seat is the ring (A), the upper, the plate (B), supported above (A) by the wings (C), and bolted to the bridge piece (D). As (B) exactly covers the opening, though at a higher level, the valve when closed is entirely shielded from the steam pressure below, so far as that power tends to lift or depress the valve; the latter is, therefore, only the recipient of horizontal pressure, consequently the valve is wholly balanced; in other words, the rod (E) has merely to lift the dead weight. Both the exhaust and steam valves are worked by means of rockers.

The engine foundation is of brick, set in lime mortar, and the whole is housed in a structure built of timber and galvanised iron.

The Jubilee shaft engine is the same type as the Birthday engine, only the cylinders are 30in. in diameter, and the winding drum 13ft. diameter, by 5ft. 1in. wide. This will be part of the permanent plant, at least until the output is so great that both shafts will have to be used for hoisting purposes at the same time. This engine is bolted down to solid rock. The engine house is of brickwork set in cement mortar, and it

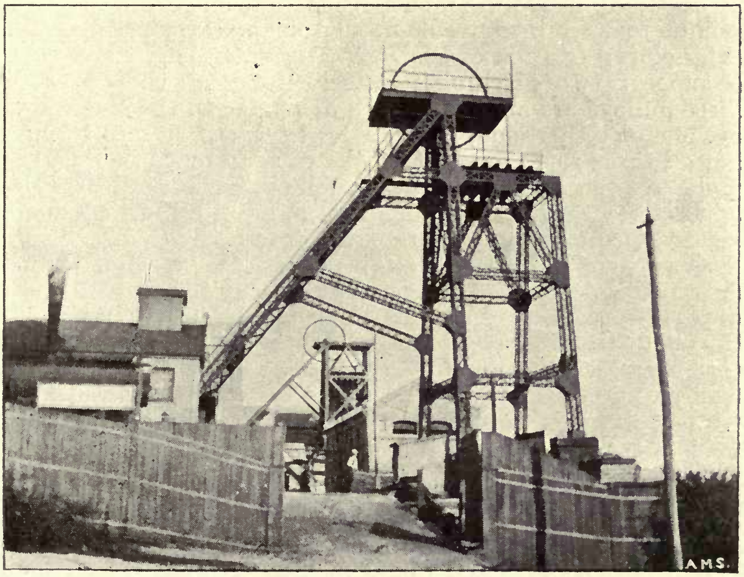


Fig. 71.—Headframes, Sydney Harbour Colliery.

has a concrete floor. The roof trusses are on the queen-post principle, the tie beams being of sufficient strength to be used for lifting from in case of necessity. The distance from the centre of the shaft to the centre of the drum is 105ft., thus giving a long lead from the drum to the pit head pulleys, reducing the side friction on the rope.

The steel head frame over the Birthday shaft (Fig. 71) was made in Nottingham, and contains 80 tons of steel lattice work and plating; the main and back legs are 2ft. by 2ft., the corner angles being 5in. by 5in. by $\frac{5}{8}$in., and straps and diagonals $2\frac{1}{2}$in. by $\frac{5}{8}$in. The front legs are also 2ft. by 2ft., but their corner angles are 4in. by 4in. by $\frac{5}{8}$in. The foot of each leg rests in a strong cast-iron shoe, set on and bolted down to massive concrete pillars resting on solid rock. The height to centre of pulley wheels is 70ft. 3in. above the pit's mouth. The pulley wheels are 18ft. in diameter, and will be placed 7ft. 3in. apart. They are made in halves, and are put together with bolts at the hub; and socket, tongue, and cotter at the rim. While sinking, a 15ft. diameter pulley wheel was arranged so that the rope passed down the centre of the shaft. The large pulley was not used in sinking, as the smaller rope employed would have worn a false groove in it which would have been detrimental to the first larger rope used for permanent work. The detaching girders, in case of overwinding, are 56ft. 3in. above the mouth of the pit, and are made strong enough to sustain a treble-decked cage, carrying six skips, each holding one ton of coal. At the same height are girders to support two 6ft. pulley wheels for the capstan ropes. These pulleys are arranged at right angles to the sinking pulley, one at either side, but at a lower level, and are so placed that all three ropes are in line; the capstan ropes then acted as guides for the cross-head above the sinking bucket, as well as supports for the bricking cradle. Four lightning conductors are arranged on the top of the head frame.

Two pairs of capstan engines are erected back to back, halfway between the downcast and upcast shafts. They are coupled, horizontal, direct-acting, with $14\frac{1}{8}$in. diameter cylinders, and 2ft. 6in. stroke, fitted with slide valves and link motion reversing gear. The crank shaft is geared down to the third motion in the ratio of 9 to 1. The third motion shaft has two drums keyed to it, each being 6ft. $4\frac{1}{2}$in. in diameter by 5ft. 6in. wide, set 8ft. apart, centre to centre, so as to correspond to the centre of the capstan pulleys on the head frame, and reduce the fleet angle. The foundations are of concrete and solid rock, and the whole is in a building of brick set in cement mortar. These engines will probably be altered to serve as driving engines for the endless rope system of haulage which it is intended to instal later on.

A nest of five boilers of the Lancashire type, 30ft. long by 8ft. in diameter, designed for a working pressure of 120lbs. per square inch, are seated in brickwork. Provision is made for increasing the number to 15, and a chamber has been built for a Green's economiser of 832 pipes. The reservoir for boiler water holds 80,000 gallons, and is built up of concrete.

The feed water is pumped by Evans compound pump in duplicate, the steam cylinders of which are 8½in. and 12in., and the rams 8in. in diameter; both rams and pistons having a 9in. stroke. The brick stack has a total height of 192ft., and forms a land-mark from the Harbour. The square base is 42ft. high, the upper portion is circular in cross section, and has an inside diameter at the top of 8ft. 2in. It is surmounted by four lightning conductors, and two tapes leading from them are grounded in the tank at its base.

When sinking, six sump holes were put in at an angle, so as to give lifting power to the shots, then while the broken rock was being sent to the surface from the sump or advanced hole formed, eight side holes were drilled vertically in the bench left round the circumference of the shaft. Rack-a-rock was the explosive used down to 650ft., after which gelignite was employed. The shots were fired from the surface by Nobel's low-tension electric exploder of the rack-bar type. The record sinking was 82ft. for the fortnight. As the rock had a tendency to flake off on exposure to the air, it was necessary to put in a temporary wooden lining till they were ready to build the permanent brick one. Curbs of 6in. by 5in. hardwood, made in 12 segments bolted together, were used at first, set 6ft. apart from centre to centre; behind these were 6in. by 1in. hardwood backing deals. Each curb was hung from the one above by hanging deals and was further supported by iron dowels let into the rock at regular intervals. Twelve hardwood punch props of 3in. by 3in. section were also set between the curbs, one to each segment. Later on, the wooden curbs gave place to rings of iron 3in. deep by ¾in. thick which were suspended from each other by iron rods 4ft. 6in. long, with hooks at either end bent in opposite directions. The iron segments were bolted together, one end being slightly bent so as to allow the straight end of the adjoining segment to fit into it. The backing deals were wedged against the walls by wooden wedges 9in. long, 6in. wide, and 2in. thick at their upper end. The brickwork was built up in sections of 100 to 150ft., according to the nature of the ground, and was started 25 to 50ft. above the bottom of the shaft, so that it should not be damaged by blasting. Walling curbs of ironbark or tallowwood, 12in. wide and 4½in. thick, were used for each section of walling. These walling curbs are made up of 12 segments which butt together, and are bolted to a cod-piece placed over

the top of each joint by three ¾in. bolts in each end. Butt joints are better than scarfed joints, as they are easier to take out later on, when the next section of walling reaches it from below. The curbs are either set on beds dressed for them cut in the side of the shaft, or if the rock is not strong enough, 18-20 two-inch iron dowels are let 2ft. or 3ft. into the side, depending on the strength of the rock, and the curb rests on them. Care must be taken to have the curbs set level and true to the centre of the shaft. The brick work is built up solid for not less than 6ft. high, after which the walling is carried up as thick as possible without cutting any bricks. The bricks should be hard, not affected by changes of temperature, and must not absorb much water. The brickwork was started with headers, the colonial bond being used, i.e., a row of headers and then three rows of stretchers. The British bond of alternate rows of headers and stretchers both keys and weathers better. The brickwork is laid in cement mortar, made of 3½

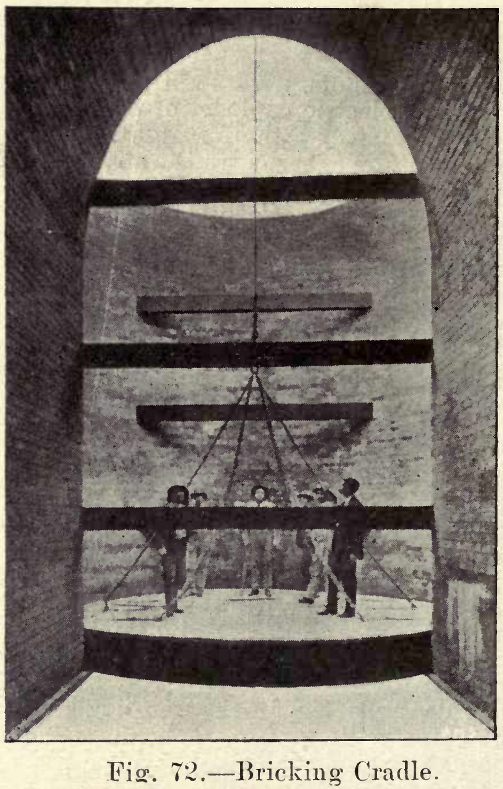


Fig. 72.—Bricking Cradle.

sand to 1 of cement. The space between the brickwork and the rock was filled up with concrete, made of sieved engine ashes and cement. The walling was carried on from a cradle (Fig. 72) suspended from the capstan ropes. This cradle or platform was a double-decker, the decks being 6ft. apart. The framework was built up of 9in. by 3in. oregon pine, placed 2ft. apart. The decks are provided with two hinged flaps, one on either side, which can be raised to allow the cradle to pass between the buntons; when down, the flaps are supported by the oregon framework below, which projects a little beyond the hinges. There is a hole left in the centre of each deck for the bucket to pass through; that in the upper deck is 6ft. square, and that in the lower deck 8ft. 6in. square, the tapered opening between the two being lined with tongued and grooved boards. There is a cover to the hatchway in the upper deck. This bricking cradle was kept in the shaft all the time sinking was going on. Its weight was about 4 tons 15 cwt., which was sufficient to keep the capstan ropes rigid enough to serve as guides for the buckets. The combined breaking strain of these ropes was 86½ tons, but the maximum load on them, if the walling cradle was suspended at a depth of 3000ft., and loaded with the customary

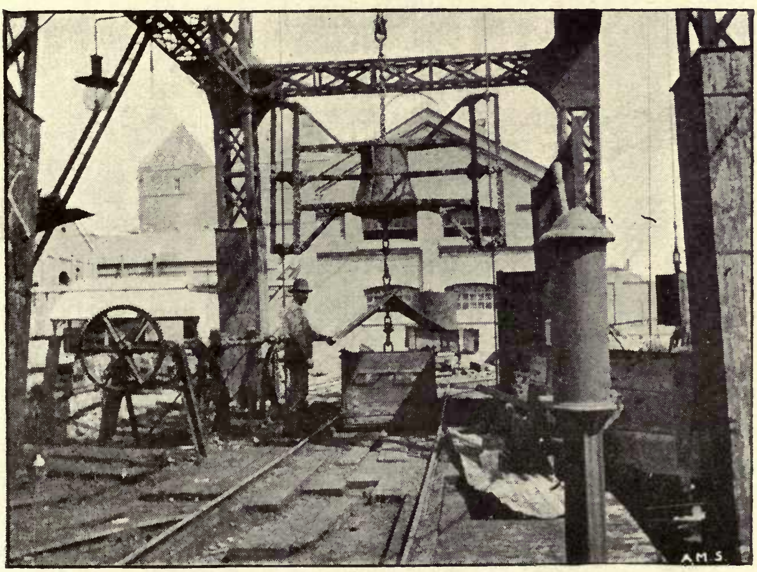


Fig. 73.—Cross-head.

complement of workmen, bricks, and mortar, was only about 14 tons at the pulleys. The use of guides in deep sinking is not only safer. but admits of increased speed of hoisting. Since the unfortunate accident, when a bucketful of men lost their lives, presumably from the pendulum-like motion of the bucket, possibly started by a slight movement by one of the occupants, a cross-head, as seen in (Fig. 73) has been used, and men when ascending or descending are strapped to the bucket.

The buntons are of ironbark, 14ft. 6in. long, 10in. deep, and 6in. wide. They are built into the walling as work proceeds, 6ft. apart vertically from centre to centre, and 12ft. 9in. apart horizontally. To each bunton is bolted two lines of steel rails on which the shoes slide, which are attached to one side of the

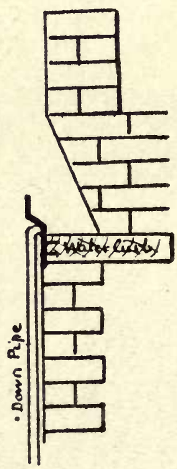


Fig. 74.—Water Ring.

cage only. Where two lengths of rails butt together they are dowelled so as to keep their ends true. While sinking, gas was found in fissures and cavities of the strata 1000ft. above the seam of coal, in some cases under such pressure as to cause the floor to lift beneath the feet of the men engaged in sinking.

In the Birthday shaft no trouble was caused by water; only about 500 gallons per hour was made. This all came from above 700ft., and was collected in a garland, or water ring. (Fig. 74). The garland consisted of steel plates, 8in. wide by $\frac{1}{8}$in. thick, fastened to walling curbs by coach screws. The upper edge of the plates was slightly dished towards the centre of the shaft, so as to catch the

water running down the side of the brickwork. The brickwork is shorn back just above the curb, so as to form a channel for the water. Two-inch down pipes lead the water to the bottom of the shaft, from which, under ordinary working conditions, it is filled with the muck; but should water accumulate, cwing to a stoppage of sinking, then it was baled out in a 250 gallon bucket, with a self-acting valve. They could only draw 80 buckets a shift. In the Jubilee shaft a feeder of water was tapped at 600ft., which yielded 1200 gallons of water per hour, and this had to be eventually dammed back with 53ft. of iron tubbing.

The wedging curbs of the tubbing, which are cast hollow, are 2ft. 6in. wide; they were made extra wide, as the rock was

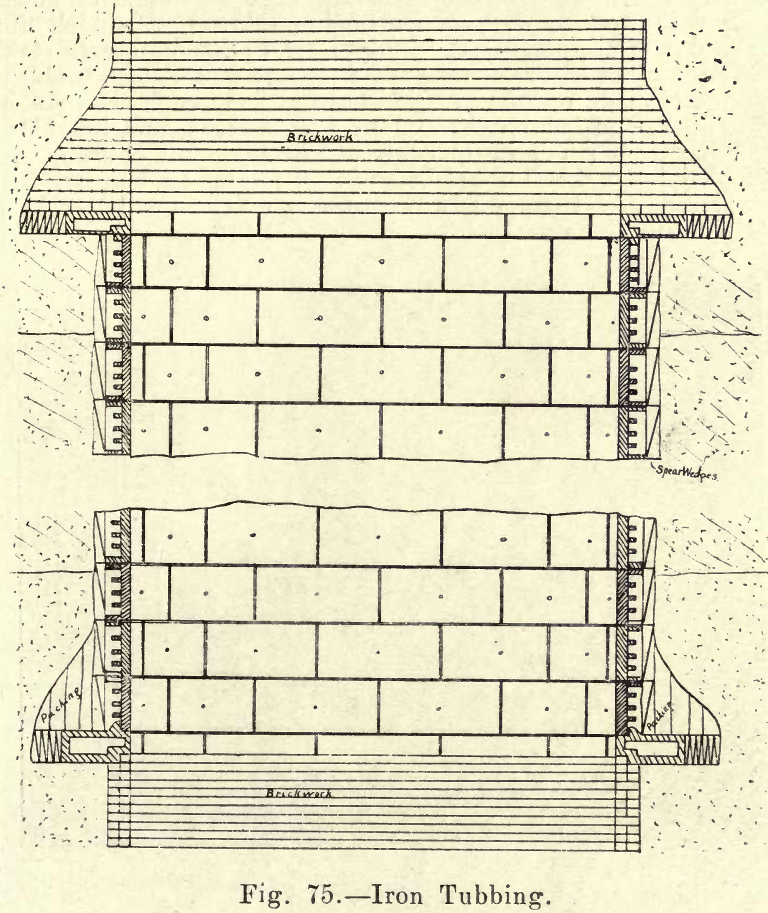


Fig. 75.—Iron Tubbing.

knocked about, and it was necessary to get into the solid. The curb bed must be cut perfectly level in rock impervious to water. The Hawkesbury sandstone is treacherous, being full of fissures and false beddings. Should the curb bed not be properly shaped and levelled, endless trouble is caused: the vertical joints are not plumb, and the thrust from the wedges behind do not bring the joints up evenly. It will be noticed from (Fig. 75) that the bottom wedging curb has a rib cast on it $4\frac{1}{2}$in. from the inner end on the top, and a recess on the bottom. The latter is unusual, but was allowed in this case for fear it should be necessary to place another length of tubbing immediately below it. The rib on the top of the curb is to prevent the first ring of tubbing from being pushed too far back. When the curb is laid it is wedged all round the outer side with wooden wedges, care being taken not to push the curb out of alignment. The wedges are driven in until a steel chisel will not enter to make room for any more. The tubbing proper is made up of 12 segments to a ring: each segment is 2ft. high, and is strengthened by ribs, flanges, and brackets, and has a plug hole in the centre. The segments of each ring break joint vertically, and between all joints wooden sheeting is placed. As there was a pressure of 600ft., the lower half of the tubbing was cast 3in. thick, and the upper half $2\frac{7}{8}$in.

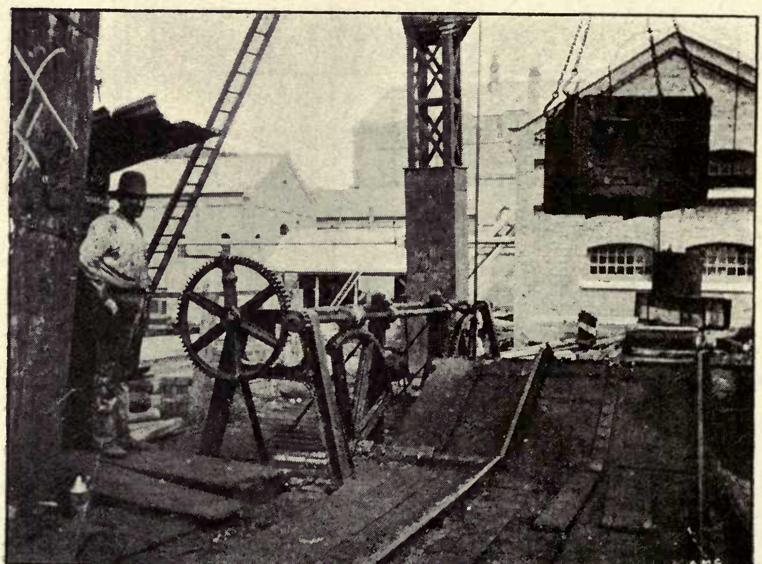


Fig. 76.—Door over Shaft.

thick; the segments weigh 18 to 19cwt. each. As the lower end of the bottom ring rests against the rib cast on the top of the bottom wedging curb, it has no flange cast on it. For a similar reason there is no flange on the upper end of the top ring. The space between the tubbing and the rock is packed with pieces of wood and spear wedges. The holding down or capping curb is cast flat on the top, and has a recess for the top ring below. This is wedged in position in a similar manner to the bottom curb, the rock being shorn back sufficiently to enable the men to get at their work. Bricks are now built up on the top of the holding-down curb. When the tubbing is properly wedged, the plug holes, which till now have been left open so as to relieve the pressure of water at the back, are stopped by driving wooden plugs into them.

While sinking, the top of the shaft was protected by a door that closed down flat over it. This door had rails fastened to it, so that a trolly could be run underneath to receive the body of a skip, or a skip itself could be raised from below and lowered on the rails to be taken to the tip. The door was in two parts, and is opened by a worm and worm wheel worked

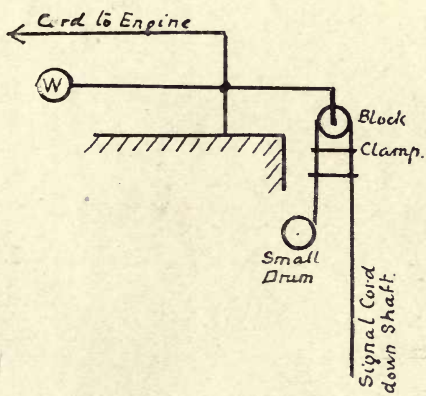


Fig. 77.—Signal Cord.

by means of a hand winch. (Fig. 76). The arrangement by means of which the signal cord is balanced and gradually let out as sinking proceeds is shown in (Fig. 77).

The head frame of the Jubilee shaft is made of ironbark timber. The sticks fit into cast-iron shoes, to which they are bolted, the shoes in turn being bolted to concrete pillars (Fig. 78). To prevent water from entering the shoes and rotting the wood, pitch was placed inside the casting, and the timber when stepped forced out the excess of pitch, then the space was caulked with tow.

A pair of compound horizontal engines, with 8in. and 12in. diameter cylinders, and 2ft. stroke, drives, by means of a belt, a Crompton dynamo of 230 volts, 112 amp., with 550 rev. per minute. This is used for electric lighting, also for driving the picking belt.

While sinking, the shaft was divided into an upcast and downcast compartment by a brattice of tongued and grooved deal boards 6in. by 1in., cut in sections at the surface ready for use, to be fitted between the buntons, and were kept in position by arris cleats top and bottom. (Fig. 79.) These angular cleats were used so as to prevent stones from lodging

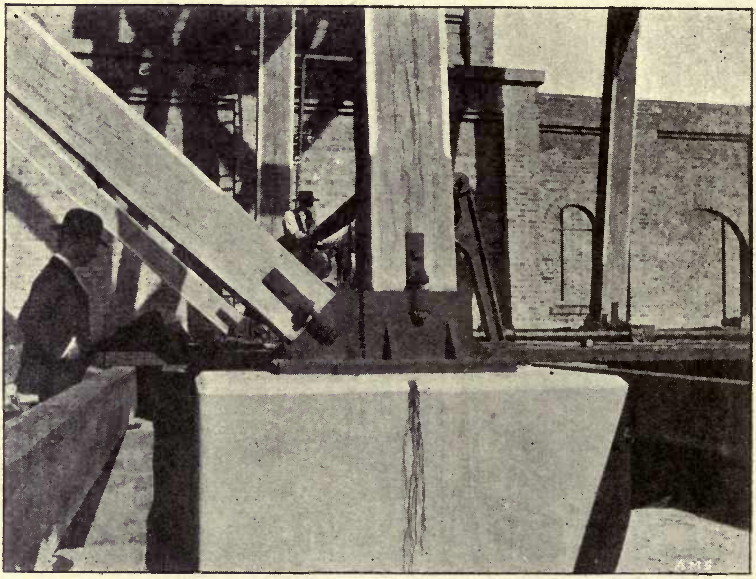


Fig. 78.—Shoes of Headframe.

on the buntons. The junction of the wood and the brick lining of the shaft was made tight by means of strips of brattice cloth. The larger compartment was the downcast, and the smaller, which was 12ft. square, was the upcast, and was connected with the air drift at the surface. At first the ventilation current was produced by means of a steam jet playing into the drift near the top of the shaft; a temporary chimney 30ft. by 3ft. square connected with the drift, increasing the height of the upcast column. To facilitate driving from the Birthday shaft, while the Jubilee shaft was being sunk, a

small Walker's fan was installed at the bottom of the upcast portion of the Birthday shaft, having a capacity of 25,000 cubic feet per minute, which was driven from the surface by an endless rope. The permanent fan is also one of Walker's (Fig. 80), 24ft. in diameter, and 8ft. wide, provided with a Walker's shutter, and guaranteed to produce 400,000 cubic feet of air per minute, with 4½in. water gauge. The driving engine is a compound horizontal, with 19in. and 25in. diameter cylinders,

Fig. 79. Wooden Brattice.

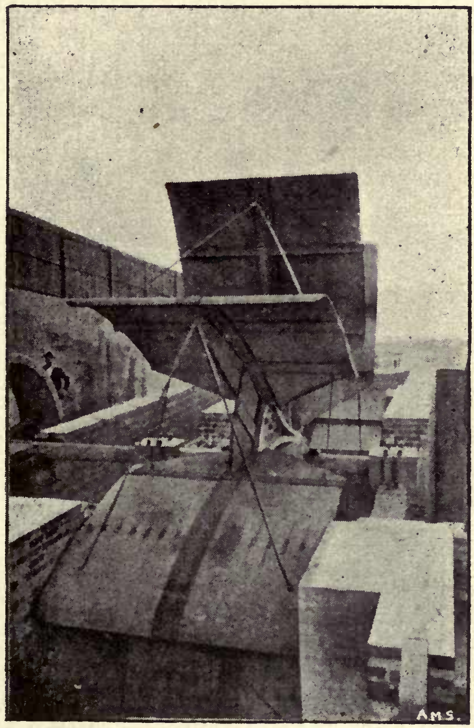


Fig. 80.—Walker's Fan.

and 4ft. stroke. It drives the fan with 11 cotton ropes, the driving pulley being 18ft. in diameter, and the fan pulley 9ft. in diameter. The engine is provided with Meyer's cut-off valve for both high and low pressure cylinders, so that steam can be regulated in either cylinder should the other have to be cut out for any reason. This gear consists of two valves, the main valve, A.B., and the expansion valve, E.F. (Fig. 81).

The main valve regulates the point of admission, release and compression, while the expansion valve is a variable one, since the point of cut-off can be varied, and this can be done while the engine is running. The two blocks, E and F, are on a spindle cut with both right and left hand threads, and by turning this, the lap is altered by either bringing the blocks together or separating them. If the blocks are brought closer together the cut-off will be later; if they are separated, then the cut-off will be earlier. When E and F are close together they are out of gear, and the cut-off is given by the main valve. The two valves moving in opposite directions give a quicker cut-off; this decreases wire drawing. The spindle is turned by means of the hand wheel G, which has a square hole in its boss for the spindle. The boss is encircled by a screw carrying a pointer H, the movement of which represents the altered expansion to the eye.

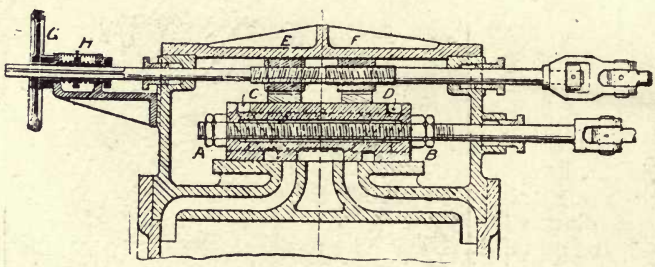


Fig. 81.—Meyer's Variable Expansion Gear.

According to Professor David, the top coal seam at Cremorne is 2850ft. below sea level. Assuming that the seam continues at the same angle, i.e., 110ft. per mile, then allowing for soundings, if the seam outcrops below the ocean, it should be met with about 18 miles east of Port Jackson heads. "It is improbable, however, that the outcrop is nearer than ten miles, or further than fifteen miles from the coast." The seam which was split up at Balmain improves at they drive east. About half-a-mile east of the shaft, the top coal is 2ft. 3in. thick, slate 1ft. 10in., and then the bottom coal 1ft. 4in. Now, at the end of the winning, the seam is from 5ft. 6in. to 5ft. 9in. thick, the coal getting thicker while the band is thinning out. At 1450 yards east, off Ballast Point, they have started to open out on the longwall system, where the coal is 5ft. thick, with one band. The two winnings are 8ft. wide, and 7ft. high. Until work is sufficiently advanced for the endless rope system, all haulage is done by horses.

This colliery is being equipped for an eventual output of 2000 tons per diem. The skips, on reaching the surface, will first be weighed, so as to ascertain the weight of coal for which

the miner shall be paid, and will then be tipped on a side tippler similar to that of the Metropolitan colliery; the coal will slide over a stationary screen, the slack falling between the bars into a billy-fair-play, while the round coal passes on to a picking belt. The slack is taken by a scraper conveyor to the boot of a bucket elevator, which raises it into a shoot. From the shoot the slack can be diverted either to a tip or into another scraper conveyor, which takes it to the boiler house. The scraper conveyor, tippler, and screen were provided by Messrs. Morison and Bearby, of Carrington, near Newcastle.

The round coal drops on to a double-headed flight picking belt, mounted on two strands of Jeffrey's malleable roller chains. This belt is arranged at an angle of fifteen degrees; is 120ft. from centre to centre, 4ft. wide, and is driven by a

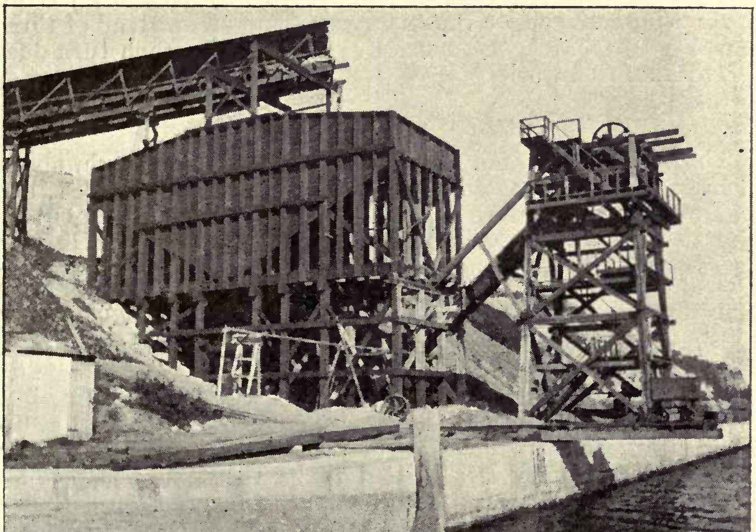


Fig. 82.—Picking-Belt, Bin, and Loading Tower.

12 h.p. motor, located near the head of the belt, at a rate of 60ft. per minute. Boys can stand on both sides of the belt to pick out stone. The capacity of the picking belt is 250 tons per hour, and it delivers into a 750 ton bin. (Fig. 82), which has four valves beneath it. A portable 10-ton Pooley weighing machine, with a dial face, can be placed under two adjoining valves, from which it is desired to draw coal. This machine

is for the purpose of noting the weight of coal shipped, and it has a capacity of 300 tons an hour. Below the weighing machine is a hopper from which the coal is fed down a spout on to a double strand scraper conveyor, mounted on two strand Jeffrey steel thimble roller chains. The conveyor is 3ft. 6in. wide, and travels at the rate of 75ft. per minute, up an incline of 38 degrees, to the top of a hardwood tower 50ft. above the wharf level. It has a capacity of 300 tons an hour if necessary, but that rate is not required, as the coal cannot be trimmed so fast. There are three points on the tower from which coal may be delivered, according to the height of the tide, and the size of the vessel. The conveyor is driven from the top of the tower by a small steam engine at the base of the bin, through the medium of a rope, which has three turns round the pulleys, and a tension wheel to take up the slack: by having one continuous rope, on the American principle, instead of three separate ropes, as is the usual English custom, each turn does its fair share of work.

The Metropolitan Colliery.

The Metropolitan Colliery is situated at Helensburgh, about 28 miles south of Sydney. Operations started here in 1887, but the first five years were occupied in shaft sinking and equipping the mine. This colliery has been worked constantly now for many years. The area controlled by the Metropolitan Coal Company of Sydney Limited is about 22,000 acres, which is the largest area held by any coal mining company in New South Wales. Some of the land is leased from the Crown, and some from private individuals. The present general manager, Mr. D. A. W. Robertson, has been in charge for nearly 19 years, and great credit is due to him for the way in which he has overcome the difficulties met with. This colliery is admitted to be the most gassy mine in New South Wales, yet there has never been an explosion, which speaks well for the care exercised by those in charge. Subsequent developments have proved that the site selected for the shafts and surface works would have been better situated about two miles nearer Sydney. The shafts were sunk in a gully which leads nowhere, and the only getaway is by a short private line connected to the main line about a mile south of Helensburgh. Certain first costs were saved in the sinking, but these were more than counterbalanced by the fact that all the ground required for buildings had to be made, also the shafts are so far apart that an entirely separate nest of boilers was required for each. Below they were unfortunate enough to encounter a fault which limited developments at first, but now they have three districts to work from, and have

30 to 35 years' supply of coal opened up. Though still developing, it is not necessary to do so at the same rate as formerly. for every foot of headings driven represents a larger spread of coal.

The two shafts are each 1100ft. deep, are circular in cross-section, and are lined with brickwork where necessary. The downcast shaft is 16ft. in diameter, and the upcast shaft 15ft. in diameter. Although the shafts are 1100ft. deep, some of the workings, partly owing to ridges on the surface, and partly owing to dip workings, have 1500ft. of cover. These are the deepest colliery workings in New South Wales if we except the Sydney Harbour Colliery, which is scarcely in the producing stage yet.

The Bulli seam in this colliery is about 11ft. thick. Only some 6ft. 6in. of the upper coal which is free from partings is worked, though the lower coal is taken up in the headings. This is good steam coal; though jointy, it is closer in grain, harder, and higher in fixed carbon than that from the same seam with less cover worked further down the coast. On account of the jointy nature of the coal, it is so easily won that less men are required for the same output than at most other coal mines.

All the hoisting and travelling is done in the downcast shaft, where the winding engine lifts a total load of seven tons, including cages, chains, load and rope from cage at bottom to pulleys, 1100ft. in 28 seconds; another 7 to 8 seconds being required to discharge loaded skips and replace with empties. The engine is capable of raising 1600 tons of coal in eight hours, but the actual work accomplished has been 1500 tons during that period. The winding engine has 34in. diameter cylinders, and 5ft. 6in. stroke. It has double beat Cornish valves and trip gear. The drums, which are placed parallel, are 15ft. in diameter. The cages carry two skips each, which are placed tandem ways, and held on the cages by stops; when the latter are depressed, the on-coming skips are made to push out those already in the cage, and take their places. The guides are made of ropes consisting of six $\frac{5}{8}$in. iron rods twisted together, so that the whole is $1\frac{1}{4}$in. in diameter. There are three of these guides for each cage, two placed on the side nearest the wall of the shaft, the other near the middle of the opposite side, but not exactly opposite the corresponding rope of the other cage (Fig. 85). They are fixed at the top by passing the end of each rope through a hole in a girder, doubling it over, and clamping with three clamps (Fig. 83). At the bottom, the guides are doubled through eye-bolts that hang loose in the shaft, and are clamped in a similar manner as on the pit-head

frame. On the eye-bolts are strung cheese-weights (Fig. 84) aggregating about $4\frac{1}{2}$ tons for each guide, so as to give it sufficient tension. Rubbing-bars are placed on the sides of the cages next each other, and are 18in. apart when the cages are stationary. Between the two cages are suspended two old winding ropes, their object being to prevent the cages from colliding (Fig. 85). One peculiar feature noticed after adopting the rubbing-bars was that the cages did not ascend in the same position that they assumed when at rest, but canted over at an angle. This was demonstrated by the wearing of the rubbing bars against one division rope more than the other: fortunately both cages canted over in the same direction, instead of towards each other. Rope guides are not so satisfactory as steel rails, now that the latter can be made straight and even; for

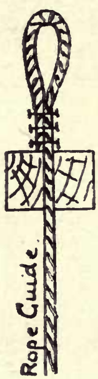


Fig. 83, Fastening of guide rope at top.

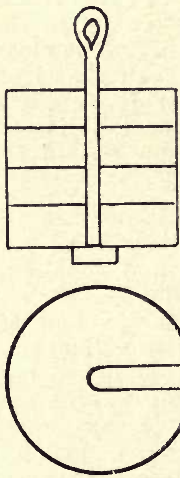


Fig. 84, Cheese weights.

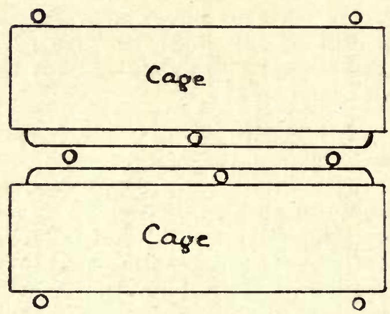


Fig. 85.—Guide Rope, Rubbing bars and Division rope.

not being firmly fixed, if steam is shut off suddenly it sets the ropes dancing, and there is danger of the cages colliding when half way. On account of the swaying of the cages, large shafts are required where rope guides are used, for sufficient space must be left between the cages, although buntons are not wanted. The deeper the pit the greater the flexibility of the ropes, for they cannot be weighted so heavily as to secure the same amount of rigidity that steel rails fastened to buntons possess, and this flexibility is greatest in the middle of their length, where the cages pass. On the other hand, rope guides are cheaper

in first cost; they offer no resistance to ventilation, as they require no intermediate supports, and take up little space; unless fixed at the bottom, they are free to expand and contract; if properly oiled they last longer than wooden guides, require less repairs, and are easily fitted up and secured.

The winding rope, which is $4\frac{1}{2}$ inches in circumference, is capped with one of Becker's caps. The ordinary way of capping by separating the wires and doubling them back over some underlying metal or other material, so as to form a cone-shaped knot at the end, destroys the unity of the wires which is essential so that the rope shall yield a tensile strength proportionate to its metallic area, and as the strain is exerted on this tapered knot, which is naturally the weakest part, the factor of safety, which is right enough for the main body of the rope, may be inadequate for that portion of it inside the cap, where the wires break one after the other, and cannot be detected. W. H. Becker designed a cap with sliding interlocking wedges hollowed out in the centre, which clamps the whole of the rope within it, and does not depend on a swelling at the end, though in practice the end is turned over, as shown in Fig. 86. A rope can be capped in 15 minutes, so, if required, the end of it can be examined daily.

Of the three endless rope systems for hauling, two ropes, each $3\frac{1}{8}$in. in circumference cross the gully, and pass down the upcast shaft direct to their work. A band rope, $1\frac{1}{4}$in. diameter, passes down the main shaft and drives several drums at the bottom, which are put in and out of gear by Walker's friction clutches. This clutch consists of three segments fixed to the drum: each segment is connected to those on either side by a left and right hand screw with large threads, so that a slight turn will cause them to come closer together or to go further apart, according to the direction in which they are turned. A boss is fixed to the drum shafting, so when the segments clutch this boss it causes the drum and shafting to rotate: it is found that when the "friction" is copper-lined it gives a better grip than otherwise. The clutch is worked by means of a hand wheel at the top of a fine threaded screw, and the motion is transmitted to the segments by a system of levers. By having a fine thread, the endless rope is started or stopped slowly, thus avoiding shock. Of the drums in this underground chamber, one is for a collecting rope that runs for about three hundred yards from the pit's bottom, it being unsuitable to have a gravity system for such a distance, besides the collecting rope controls the traffic better; another is for the main haulage, and like the other main haulage ropes is of the best plough steel $3\frac{1}{8}$-inch circumference; while a third is a driving rope for working two secondary haulages in two headings, the ropes of which are

$2\frac{1}{2}$in. in circumference. In addition to these there are two endless rope self-acting inclines. From a drum in the chamber near the main shaft bottom already referred to, power is transmitted by a band rope laid along the centre of the main dip road to chambers fitted with friction drums at points one mile, and one and a quarter miles distant from the shaft. These drums in turn operate two secondary rope haulage systems, east and west, for the conveyance of coal, from points where same is delivered by horses, to the main dip. The dip of

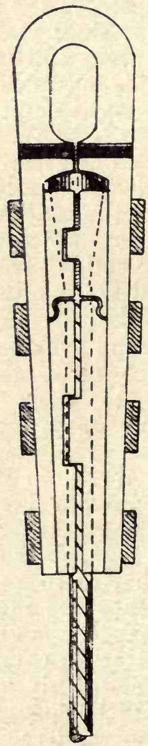


Fig. 86.—Becker's Cap.

the coal is very irregular, hence the collecting work from the working places by horses is unusually severe, and some 55 heavy draught horses are required. These horses are stabled underground in the vicinity of the air shaft. The stables are brick lined, floored with wooden blocks, and lighted by electricity.

There are five main parallel headings: the three in the middle are intakes, while the two on either side are returns. The

centre heading is used for the main haulage, while the other two intakes are for travelling roads. Cross-headings are started about every quarter of a mile, or 440 yards.

The Welsh-bord system of extracting the coal was adopted for the sake of better ventilation, but where the roof is bad it is found advantageous to modify this. On account of the depth at which the coal is found, and character of roof. stronger props than usual are required, the minimum size being seven inches in diameter, and on account of the large amount of gas present, more air is required for ventilation purposes, which are factors that had to be taken into consideration. The Welsh-bords are made ten yards wide, about 200 yards long, and have a pillar 50 yards wide between them. In

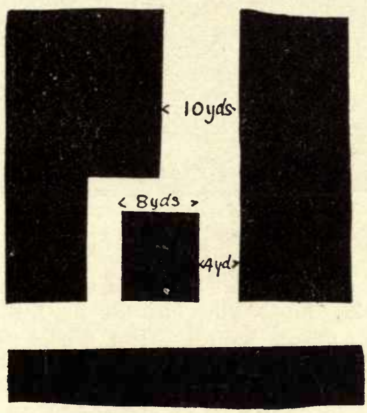


Fig. 87.—Opening Out of Bord.

the ordinary pillar and bord, any waste is thrown on both sides, while a roadway is kept open in the middle: with the Welsh-bord system, the waste is stacked in the middle, and a roadway left in either side. When starting a bord off a heading, two passages are commenced, each four yards wide, and about ten yards long, leaving a pillar eight yards in width between them: one of these passages is continued straight on (Fig. 87), the other off-sets towards the first; they are then carried on together for the full width of the bord. When extracting the pillar it is attacked from one or both bords, in strips 10 to 20 yards wide (Fig. 88), a roadway and pair of men working every five yards of width. One of the roadways in each bord is abandoned for hauling purposes, whichever happens to be in the worst condition, but it may still be used for ventilation or inspection purposes, unless the roof proves too costly to

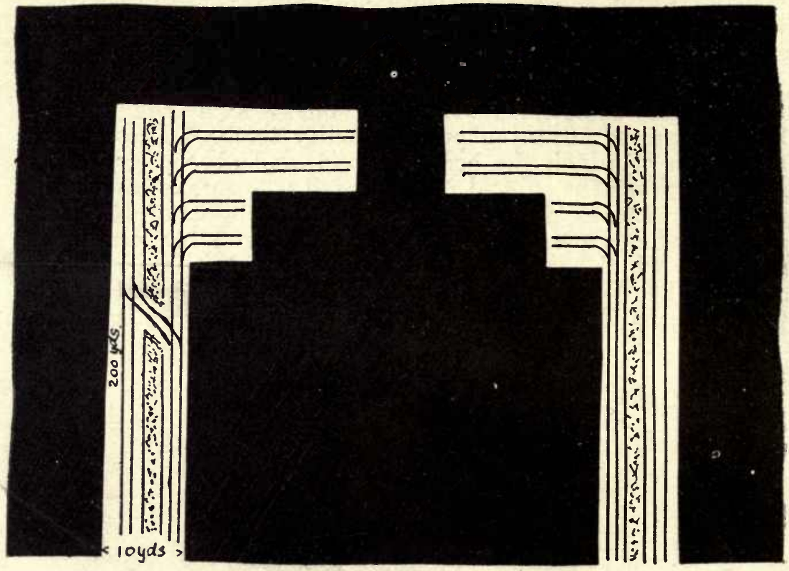


Fig. 88.—Welsh Bord System.

maintain. Holes have to be made in the goaf to convey air to the parallel road. The holes cannot be left as the bord advances, since the crush would often close them up; besides, though closed by brattice, the air is apt to short circuit when holes are made before they are required. It is noticed that the roof becomes heavy about 30 yards ahead of where the pillaring is taking place. With the modified method (Fig. 89) a pair of four-yard headings are driven with a pillar of 24 yards

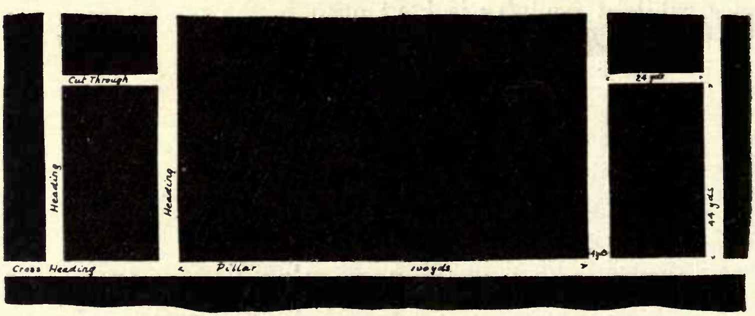


Fig. 89.—New Method.

between them, cut-throughs are made about every 44 yards apart; between each pair of headings is a pillar 100 yards wide. This method requires narrow-work, but the expense of supporting the roof is less, and the pillar between each pair of headings is double the width of that left by the old method, so they do not have to be put in so often, also there are no small holes to be made through the goaf in the bords as with the old method. The pillars are worked out on the same principle as before; the wider they are taken out the less trouble they cause. From two to four roadways are turned off from the end of a heading on either side of a pillar, depending on the width of the pillar strip to be extracted at one time; these are extended as work proceeds, and when one strip is completed, the rails are taken up and used for the next strip. The coal requires little or no holing, so is unsuitable for coal cutting machinery. All the filling into the skips is done by fork. There is practically no water in the mine, so the workings are very dusty.

Four hundred thousand cubic feet of air at five inches water gauge pressure pass through the mine per minute, and the return air contains 1¼ per cent. of fire-damp. There are two Walker-Schiele fans, each driven from horizontal engines by fifteen manilla ropes, but only one fan is worked at a time. The bigger fan, 24 feet in diameter, by 8 feet wide, revolves 106 times per minute, and is driven by a compound engine having 23in. and 36in. diameter cylinders with a three foot stroke. The other fan is 20 feet by 7 feet wide, has 130 re-with a 36in. diameter cylinder. Being driven at such a high speed, the bearings of these fans have to be kept cool by streams of water playing on them. The air drifts are so arranged that they can be put into communication with either fan by means of doors. A large iron framework is built across the drift on each side of the fan, and in this are three pairs of iron doors, one above the other, that open towards the fan. These are of such a size that they can be easily manipulated, and as they move in the direction of the air current, they require no special fastening. Underground the fresh air from the down-cast shaft passes along the intake headings, and returns partly along the return headings, and partly along the disused or partly disused workings. The aggregate amount of air circulated by the two fans is not only the largest in Australia, but is probably greater than that produced in any one mine elsewhere.

The upcast shaft is housed in with brick walls, provided with windows, and roofed with galvanised iron, so in case of an explosion this would give way readily, and save the fans from being disabled. The pit-head frame is of timber, the sills of which are mounted on brick walls. An emergency winding engine is located at this shaft, and single skip cages

are suspended ready in the shaft: the guide ropes are situated at diagonal corners of the cage, two to each cage. The steam power for this pit is provided by three Lancashire boilers. The electric light is generated by two Siemens direct-current dynamos, driven by two vertical engines of Tangyes' make. The larger of the two dynamos is 10kw., 45.5 amp., and 220 volts. The electric light is used at the surface, and also about the pit's bottom. At the main shaft is a steel pit-head frame of English make. The full skips, after being weighed near the pit's mouth, are conveyed by means of a creeper-chain up an incline to the tipplers. After being emptied, the skips are conveyed along a level place by means of another creeper-chain, and are then sent down a pair of rails curved first in one

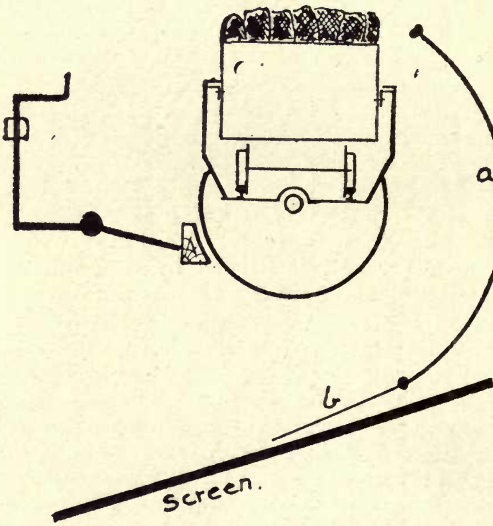


Fig. 90.—Tippler.

direction horizontally and then in another, so as to gradually break their impetus till they reach the mouth of the pit again. A piece of angle iron is fastened to either side of the skips so as to hold them in the tipplers. Mr. Robertson maintains that it is not the speed at which a tippler revolves that breaks the coal, but the drop the coal is given, for if a box of coal be quickly and completely turned upside down on to the ground the coal is not disturbed and shaken to the same extent as if it were spilt from the height at which it started. Carrying out this idea, Mr. Robertson devised a tippler that revolves on an axle in such a way as to leave the skip open on the top. In order to keep the coal in the skip till it reaches the screen, a

curved sheet iron shield (Fig. 90) (a) is hinged at its upper end in such a manner that it presses against the coal in the skip, which it keeps in place until the skip is almost reversed; being on a hinge this shield can adjust itself to the height of the coal above the sides of the skip, and swings back into place as soon as the skip passes it. At the bottom of this curved sheet is hinged a flat piece of sheet iron (b) to guide the coal on to the screen. the free end sliding up and down on the screen according to the distance the shield is pushed out of the perpendicular. In this way the coal may be tipped quickly, and still be retained in the skip till upside down, when it is delivered on to the stationary screen with the least possible shock. There is a brake connected with the tippler, because it is found that by its use the coal spreads, and is better screened when eased down than when dumped in one heap; in the latter case the coal tends to slide down bodily, which does not give the slack sufficient chance to pass between the bars.

The main screens just separate the coal into round coal and slack. The slack is raised in a bucket elevator to two shaking screens worked together by means of an eccentric. The upper screen has a half inch mesh, and the lower three-sixteenths of an inch. It was found that the dust was separated better by getting rid of the larger pieces first. The oversize from each screen is mixed and sold as "nuts" for use in boilers fed by mechanical stokers. The slack that passes through the bars of the main screens is collected in the box of the billy-fair-play, and weighed by a large spring balance before being discharged through the movable bottom.

The mouth of the pit is protected by a sliding gate at each entrance to the cage, which gates are lifted by the cage as it ascends, and is lowered as it descends. To reduce the jar, the shaft gate falls on rubber buffers. In order to steady the cage and keep it in position, as it approaches the surface, angle irons are fixed to guide the corners of the cages, also pieces of bar iron at either end.

Electric signals are employed: for these Leclanche batteries are used with relays.

Near the main shaft is a nest of eleven Lancashire boilers imported from England, nine of which are fitted with the Meldrum system of forced draft.

The Cambrian safety lamp is the one used by the miners; in these is burnt a mixture of three parts of colsa oil to one part of kerosene. This is found to be more sensitive than the colsa oil alone, and does not crust the wick so much. The object desired is to obtain a serviceable and at the same time a sensitive oil. With colsa alone, one cannot determine less than three per cent. of gas in the atmosphere; while with kerosene, one

can detect three-quarters of a per cent. The officials use Hepplewhite-Grey lamps, and test for gas with the hydrogen flame. It takes a man and three boys one minute to take to pieces, clean, fill and put together again three lamps. One boy takes the lamp apart; the man cleans and examines the gauzes, for this he has two revolving brushes, one for the inside, the other for the outside of the gauze cylinders; a second boy cleans the glasses, and a third boy fills the oil vessels and puts the parts together. A fourth boy is employed on night shift.

Only one shift is worked at this colliery. The front and back shift system is not employed here as in the tunnel collieries down the coast, for as the only means of ingress and egress is by the cages in the shaft, it would necessitate the employment of extra engine-drivers; besides, the coal is so easily won that it requires no preparation by holing and blasting to fetch it down, so there is no occasion for a man to get the place ready for his mate. After interviewing the examining deputy at his station, the men proceed with their work at their own discretion, and can have a snack when they please. The wheelers, of course, have a fixed half-hour for dinner. The men are searched for pipes, tobacco and matches before descending in the cage, and at frequent intervals five or six cages of men (16 in a cage) are searched immediately they reach the pit's bottom in the morning. A special search is made at irregular intervals, when officers, working in pairs, thoroughly search the clothing of every person throughout the mine while at their working places: precautions being taken that no previous warning is given.

The output from this colliery is practically absorbed by inland consumers, the demand remaining unsatisfied. Fully 200,000 tons of this coal is taken annually by the Government railways and tramways.

Coal Cliff Colliery.

This colliery, which is situated at Clifton, is of special interest, for it was here that coal was first discovered in New South Wales, in August, 1797 (Fig. 91.). It is owned by Messrs. E. Vickery and Sons Ltd., and is managed by Mr. P. J. Carrick, who has been in charge for the past ten years, but has been employed at the colliery for twenty-seven or twenty-eight years. The mine itself has been worked for about thirty-two years.

The seam, which averages about six feet in the workings, crops out on the side of the cliff close to the sea near the company's jetty. The collieries south of this property can be entered by means of tunnels, while north of this property the only means of access to the workings is by pits.

The Coal Cliff collierv is worked from two tunnels, one serves as an intake, the other as a return air-way. The work ings are divided into two districts; the Western and the Northern. Cross-headings branch off from these tunnels seven and a half chains apart, and bords are worked from each side of a heading so as to meet those coming towards them from the cross-headings on either side. When about to draw pillars, reads are turned off to right and left from the bords to the pillars on either side, a twelve foot lift is then taken off at a time across a pillar. When about half the length of the pillar has been extracted, the props are drawn and the roof allowed

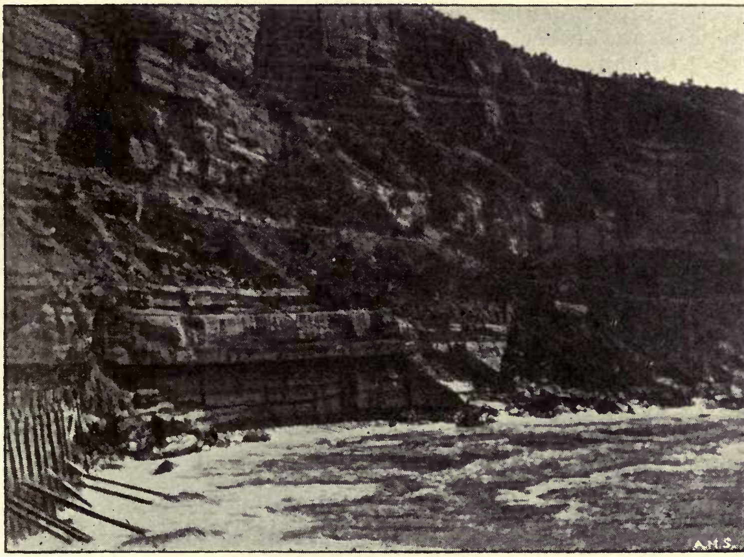


Fig. 91.—Outcrop of Coal at Coal Cliff, where Coal was first Discovered in N.S.W.

to fall in. This relieves the pressure on the coal ,thereby keeping it in better condition.

Formerly this mine was ventilated by means of a furnace, but this has been superseded by a seven foot Schiele fan, travelling three hundred revolutions per minute, and producing 15,000 cubic feet of air per minute. The Schiele fan is one of the smaller type of enclosed fans which is placed eccentrically within its casing, the casing being made a gradually increasing volute. The air enters equally from both sides. The blades are made wider near the centre than towards their tips where, on account of the greater circumference, the same

quantity of air is able to pass through a narrower space. The sides of the casing are made to taper with the blades. The tips of the blades bend away from the direction of motion. The fan is driven by a single cylinder horizontal engine of 10 horse power, supplied by H. P. Gregory and Co., of Sydney.

The water in the mine is partly fresh from surface drainage, and partly brackish. The Northern District is thirty feet below the level of the sea, but several chains inland. There are two pumps employed to drain the mine, one a single acting 2½ in. plunger pump worked off the tail rope, which is given a turn round a pulley; the other a geared ram having a 3 in. delivery pipe. The latter pump, together with a Stephenson Rocket oil engine for driving it, was supplied by Robt. Stephenson, of Westminster. At first the porcelain ignition tubes of the engine gave trouble by breaking, but now the blacksmith makes steel tubes which work well.

The skips are gathered by horses of 15 or 16 hands high, but for any specially low places, ponies are used. The horses are stabled at the surface. The skips are hauled in and out of the mine by a main and tail rope system, at a rate of about twelve miles per hour. The main rope is 3in. in circumference, and the tail rope 2½in. This system is employed in both the Northern and Western Districts, but as there is only one engine for the two districts, only one district can be worked at a time. The connection for either district is made a short distance from the entrance to the mine, where the return line for the empties of the Northern District cuts through the kip of the Western District, the space being bridged over by loose rails when it is required to draw out from the Western District. The ropes are wound up on drums by a duplex engine of Tangyes' make, K size, geared 3 to 1. The drums are thrown in and out of gear by means of claw clutches, and strap brakes are situated between the drums. This engine is installed in a chamber underground, where it is protected from the sea air. Communication along the haulage ways and the engine-driver is made by means of electric signals in the usual manner. Steam for the various engines is generated in a Cornish boiler at the surface.

At present the colliery is dependent on water carriage, both for its stores and as a means of transport for its coal, except a limited amount of stores that is lowered down over the cliff from the main road in a box which is worked up and down an aerial rope by means of a friction winch that is usually employed in hauling skips of slack to the top of a storage hopper. Convenient as sea carriage may be as the jetty goes straight out into the Pacific Ocean and has no protection from the waves and sea breezes, there are times when the company's steam-boats cannot lay along side, but it is understood that

there is a scheme on hand when by working from a pit, coal can be raised to the level of the railway which cuts through the property.

The coal on issuing from the mine is tipped on to short stationary screens; the slack that passes between the bars is hauled by ropes up an incline to the top of hoppers. The round coal and any unscreened coal to be shipped is hauled to the end

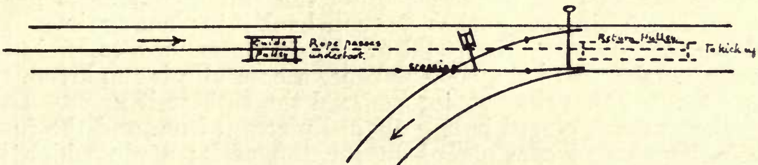


Fig. 92.—Switch.

of the jetty by means of an endless rope, the terminal pulley of which is placed vertically under the decking. (Fig. 92.) The trucks are caused to go up one end of a slight double incline or kip made by placing beams on the decking, which serve as longitudinal sleepers for the rails. When released from the endless rope, the trucks run down by gravity to an end tippler. (Fig. 93.) When emptied, the truck is switched

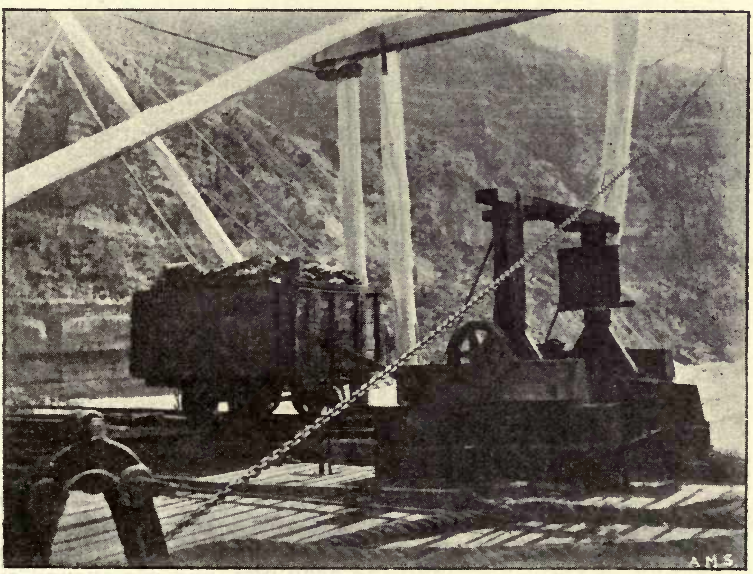


Fig. 93.—Tippler at End of Jetty, Coal Cliff.

on to a siding, along which it passes either to the slack hopper to be refilled, or to one of several storage tracks according to requirements. As one end of the kip crosses the outer rail of the siding, in order to enable the empty truck to pass, a groove is cut out of the timber of the kip while the rail above it is hinged so that it can be slid out of the way, being kept where placed by a counterweight; the full truck, as it goes towards the tippler, pushes the rail back into place again. As the ordinary screw clip would not be strong enough to hold the large trucks on to the endless rope, a cam clip is employed, so constructed that the heavier the load the tighter it grips. The endless rope is placed in a U shaped piece of iron, and the foot of a leg-shaped cam placed on the top of it; a pin which is fastened to the apparatus by a light chain is then passed

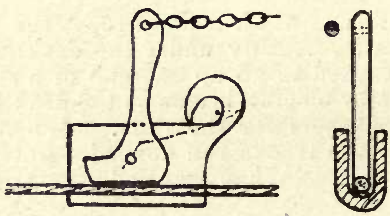


Fig. 94.—Cam Clip.

through holes in the sides of the U piece and the cam. (Fig. 94.) The rope is still free to circulate through the clip, but when a chain fastened to the lever end of the cam is hooked on to a truck, the weight of the truck causes the cam to grip the rope firmly.

The South Clifton Colliery.

This colliery belongs to the South Clifton Coal Mining Company, and has been under the management of Mr. John Wilson for the past five years.

The seam varies from 4ft. 3in. to 5ft. 6in. in thickness, it is practically free from bands, and carries very little pyrites. The coal outcrops along the coast about 166ft. above sea level. It has a strong sandstone roof that requires very little support, and a shale floor. There is no distinct facing, as is the case with the coal of the Newcastle district, but this is not necessary, as the coal is readily broken down by pick, without any holing. The Welsh bord system of mining is employed, but the bords are not filled up between the roadways, as there is no waste to fill with. The bords are turned off at right angles to the headings, and are opened out 12 yards wide, the pillars left between being 35 yards wide. No pillar extraction has been done by the present management.

When necessary to blast down the coal, holes are bored with augers, and charged with monobel; for shooting in rock, saxonite is used.

Men enter the colliery from a tunnel driven in the side of the cliff overlooking the ocean (Fig. 95); there are besides two shafts which are circular and brick lined. The downcast shaft is 150ft. deep, and is used for hoisting purposes; the upcast air shaft is 120ft. deep. The cages in the downcast shaft run on iron rail guides; these guides, two for each cage, are both arranged near the outside of the shaft, so as to give more clear-

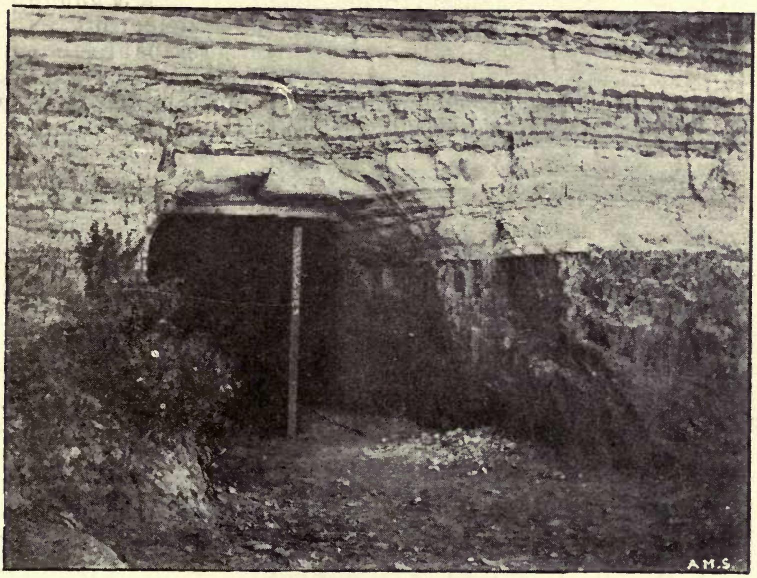


Fig. 95.—Entrance Tunnel.

ance in the shaft. The winding is done by a duplex engine, with 1ft. 6in. diameter cylinders, and 3ft. stroke. There are double drums 7ft. 6in. in diameter, with a brake path between them. The engines are direct-acting, and occupy 12 seconds to hoist a cage from the bottom; they are provided with link motion reversing gear. Steam is shut off about half-way. The rope is 4in. in circumference, and is 220ft. long from the pit's bottom to the drum. A dial indicator shows the position of the cages in the shaft. The pit head frame is built up of squared timber, on which is mounted pit head pulleys 10ft. 6in. in diameter. Steam is generated in two Lancashire boilers 30ft. long, by 7ft. diameter, and one Cornish boiler, under a pressure

of 65 to 70lb. per square inch. Below, there are two intake roadways, one from the downcast shaft, the other from the travelling roadway; and there are two return roadways to the upcast shaft.

The skips, which hold 15cwt. of coal, are made of tallow wood sides one inch thick, the boards being 11½in. wide. The skips are 4ft. 4in. long, 3ft. 6in. wide, and 23in. high; the boards are connected together by angle iron, and have a wrought iron rim round the top. The bottom is of 3-16in. sheet iron. The cast iron wheels, 11¾in. diameter, are fixed on to 1¾in. axles. To prevent skips from being filled so full that the coal is knocked off against the roof in low places, a gauge is erected, which consists of a horizontal piece of timber protected by iron, placed across a track under which the skips are obliged to pass. In the bords, short lengths of bridge rails are used. These are lighter than solid rails, and being in short lengths are easier to handle and bring close up to the face of the coal.

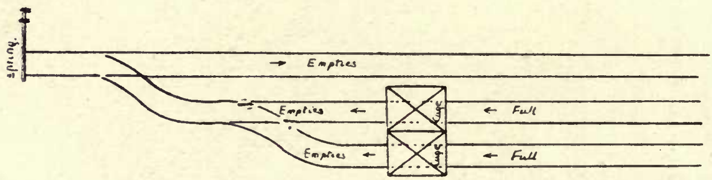


Fig. 96.— Track Arrangement at the Pit's Bottom.

The air current is circulated by means of a 20ft. diameter Walker fan, which is worked at a pressure of about 2.25 inches water gauge, and supplies 60,000 to 80,000 cubic feet of air per minute, the fan being given 80 revolutions per minute. It is driven direct by a tandem compound engine, but only the high pressure cylinder is used at present, the low pressure cylinder being disconnected.

Haulage underground is carried out by means of the endless rope system. At the bottom of the pit the empty skips are pushed off the cage by the full skips which replace them. Each empty skip then runs down a siding by gravity, at the bottom of which it strikes a wooden spring, consisting of a plank fixed at one end only. This starts the skip down the in-bye track to the place where it is attached to the endless rope by clip (Fig. 96). The greaser for the skips is placed as usual between the rails, but the pair of wheels that convey the lubricating oil from the wooden trough to the skip axles have a series of arcs of circles cut out of their periphery. into which the skip axles fit and turn the greaser, so it does not require any springs, as in the case of greasers that revolve by friction.

The endless hauling ropes are Lang's lay, with an iron core. The main rope is 3½ inches in circumference, and passes down

the main shaft, being set in motion at the surface by a duplex engine, with 12in. diameter cylinders, and 24in. stroke, provided with link motion reversing gear. The rope drum is worked on the third motion, being geared 15 to 1, thus making the rope travel at the rate of $1\frac{1}{2}$ miles per hour. The rope is given four and a half turns round the drum, the face of which is slightly inclined so that the rope is let on at the side with the greater diameter, and passes off at the smaller diameter. The tension pulley is arranged near the bottom of the pit, and the trolley on which it is fixed is attached to weights hung on a bail by means of a chain. There are three districts, each

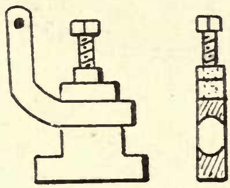


Fig. 97.—Screw Clip.

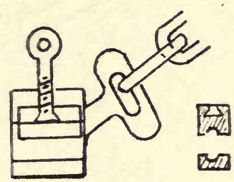


Fig. 98.—Screw Clip.

having a separate endless rope: the branch ropes are $2\frac{1}{2}$ inches in circumference, and are driven by the main rope, which also works a small geared pump. The branch ropes are put in and out of gear by Fisher's friction clutches. Three skips in a set are fastened to the rope by one clip. There are two kinds of screw clips, one worked by a spanner, the other by an iron rod (Figs. 97-98). At the top of an incline, where it was found the skips were liable to become derailed, high bar irons are placed between the rails, bent towards each other in the direction of the oncoming skips: these serve to guide the skips on to the rails again.

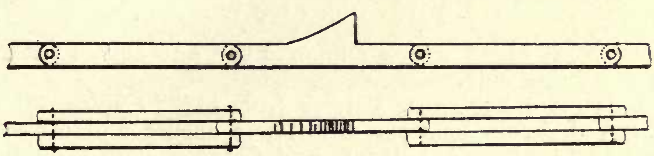


Fig. 99.—Creeper Chain.

At the pit's mouth the empty skips are drawn up an incline by a creeper chain, the links of which are 12in. long. The single link every nine feet has a horn on it high enough to catch the axle of the skip so as to pull it along (Fig. 99). The creeper is driven by a sprocket wheel and chain arranged at its lower end. The skips run down a short incline towards the shaft, the wheels of alternate skips pushing a lever on opposite

sides which works points automatically, and directs the skips to one or other of the compartments ready for the upcoming cage. Just in front of the shaft is a stop between the rails of each track to prevent skips going too far. This consists of a hook which moves on a pin: the hook is high enough to engage the axles of a skip, and is kept up by the greater weight of the tail end. When desired to release a skip in order to cage it, a lever worked by the foot depresses the hooked end by raising the weighted end of the stop (Fig. 100). At the screen siding,

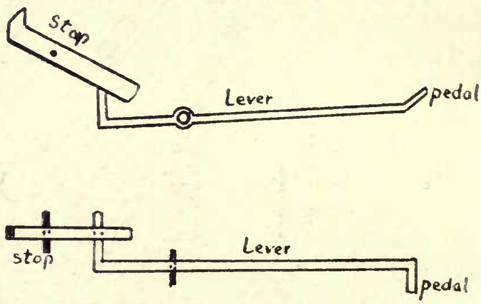


Fig. 100.—Stop.

wooden blocks shod with iron are used to prevent trucks from going too far (Fig. 101). When desired to allow a truck to

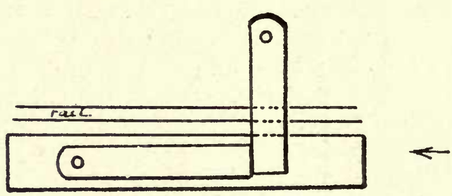


Fig. 101.—Block for Waggon.

proceed, that block which supports the one across the rail is pushed on one side.

A dynamo by Thos. Parker Ltd. of 220 volts, 25 amp., having 720 revolutions per minute, is used for electric lights at the surface, pit's bottom, and flats, it also provides the motive power for machinery in the shop, and a three-throw pump underground.

Signals are given along the roadways by means of electric wires 10 S.W.G., and a battery of Leclanche cells. Communication between underground and surface is made by ordinary wall telephones, with no special protection against dirt.

On account of the low roof only ponies between 11.2 and 13.2 hands high can be used. These walk into the mine through a tunnel, but do not come out again until it is neces-

sary to give them a spell. The underground stables have accommodation for 60 ponies, and are in charge of two hostlers. According to the grade of the track leading to a gathering station or flat, two ponies may be necessary to pull one full skip, or one pony may draw one full skip.

The lamp cabin is a compact room with barred windows, through which the men are handed their lamps. The safety lamps used are of the bonetted deflector type, made by Messrs. R. Johnson, Clapham and Morris Ltd. (Fig. 102). The oil chamber is a brass casting, in one piece, the bottom not being soldered on separately, as in lamps of other makes, such joints

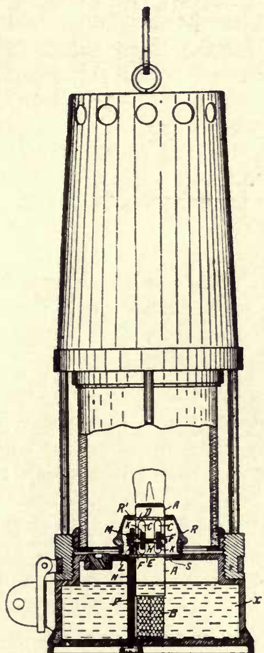


Fig. 102.—Johnson, Clapham and Morris Safety Lamp.

being weak points through which oil leaks. The wick used is flat, and it is raised or lowered by turning the thumb screw (Q), which causes the spindle (P) to revolve. This spindle has a worm (M) at the top end, which engages with a wheel that moves those (K) which works the wick up or down. With such an arrangement there is no danger, as with the ordinary pricker, which might drop down, and the top portion accidentally become pushed into the wick, then if the lamp be placed on a flat surface the pricker is pushed up, and with it the wick

causing a flaring flame. There is a feed hole on the top of the oil vessel at one side protected with a screw plug. Pure kerosene is used as the illuminant: this gives a sensitive flame for ordinary gas testing, and does not give a charred wick, which requires constant trimming. There is a movable ring to which the hasp for locking the upper part of the lamp to the oil vessel is attached, so should the screw get worn by constant use, the lamp can still be screwed up tightly and properly locked. Any part of a lamp is interchangeable with a similar part of another lamp of the same make, as the lamps are all made to template. A cone is placed round the wick to keep out dust and hold the wick in place; the cone is nickel-plated so as to act as a reflector. Above the glass are two gauzes, one inside the other. These gauzes have what is known as a metallic seam, that is the edges of the gauze are bent backwards on themselves longitudinally, and are then clamped by a strip of metal, the edges of which are bent round in the opposite direction, so as to fit in the hooks formed by the gauze. Should the gauze become crushed, it can be opened out again without splitting the seam, which often happens when the seam is wire sewn in the usual way. The lamps are lighted by means of electricity, which causes a platinum wire across the top of the wick to become red hot. Being lighted just before the men want them, there is no waste of oil, as there would be if the lamps were lighted by match, and locked ready for the men.

A tell-tale board is placed in a position so that the men have to pass it going to their work. Each man, before going to his place, puts a metal disc stamped with his special number on a certain peg: by this means the officials can tell who is underground. On returning from work the disc is removed to another part of the board. Non-compliance with this regulation makes a man subject to punishment. The men only work one shift. They start work at 7 a.m., knock off at 9 a.m. for half an hour, to have breakfast, then work till 12.30 p.m., when they take till 1 p.m. for dinner, after which they work on till 5 p.m.

The coal is tipped on to shaking screens from a cylindrical side tippler. The tippler is put in motion by means of a lever which brings friction gear into action. The present friction pulley has a rounded face, but the next tippler will be given a V-shaped face, with a truncated point. The tippler itself revolves on wheels. This class of tippler is slow, but for that reason is more suited for soft coal, such as it has to deal with, as then it is less likely to break up. The screens make four sizes of coal—1st, round; 2nd, large nuts; $\frac{3}{4}$-$\frac{5}{8}$ in., 3rd, small nuts, $\frac{5}{8}$-$\frac{3}{8}$ in.; 4th, duff, or dust. The large coal, and some unscreened bunker coal is sold, the small nuts and duff are coked and sold to smelting works. The coal before going to

the coke ovens is reduced in a disintegrator, it is then conveyed along a trough on the top of the rows of ovens by U-shaped scrapers. When desired to fill any particular oven, a slide is withdrawn from the bottom of the trough, so that the fine coal can pass down through a portable shoot and the crown of the oven (Fig. 103). There is a bank of 24 beehive ovens, with a flue in common, leading to a brick stack, and another of six ovens, with short chimneys, one between each two ovens placed back to back; 16 new beehive ovens were in course of construction at the time of my visit. The ovens vary in size.

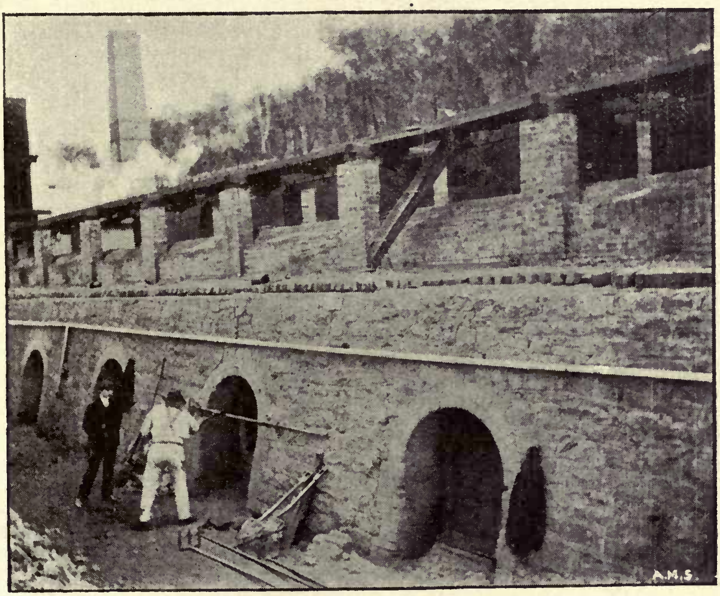


Fig. 103.—Coke Ovens.

A 5-ton oven will yield about three tons of coke, and takes about 60 hours to burn. The coke is quenched by playing water on it in the ovens, after which it is handled with 15-tine forks, the tines being 1in. apart.

North Bulli Colliery.

This colliery may be looked upon as the youngest producing colliery on the South Coast, but it is rapidly pushing its way to the front under the supervision of Mr. T. Cater, who is a large shareholder in the company.

At first, when the seam was thin, from 2ft. 11in. to 3ft. 6in., the coal was extracted on the longwall system; but where the seam increases to 4ft. 6in. and over, a change is made to pillar and bord, as there is not sufficient stone to support the roof when required. The face of the longwall is semi-circular in shape, and stall-roads leading to it are 10 yards apart from centre to centre; they are kept open by pack-walls built up of stone lifted from the bottom (which is shale, and easier to work than the sandstone roof) in order to obtain head room. The longwall method depends largely for its success on the travelling weight of the roof, which rolls forward and bears down on the strip of undercut coal at the face, causing it to fall. The rock overhead may be divided into two parts according to its action: 1st. the underweight or fractured material (A) Fig. 104. below the arch, and the

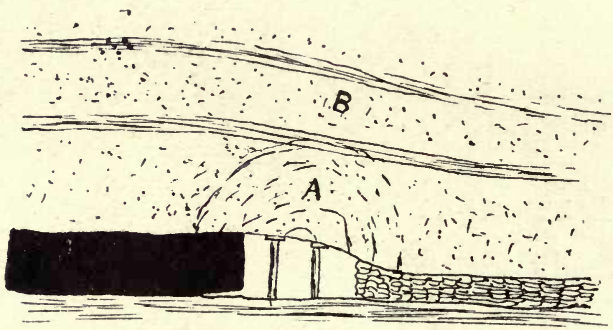


Fig. 104—Weight of Roof.

overweight or solid strata (B) above the arch, which settles on the packs behind, and keeps pace with the travelling or underweight. The roof at North Bulli fractures 15ft. to 16ft. behind the face, and the overweight crushes the packs to about half their original size. Though roof pressure cannot be overcome, it can be regulated by constant work, and a uniform line of face, so that it is just sufficient to break down the strip of undercut coal. If too great, the roof pressure will crush the coal, and may cause the roof to break off short at the face. The systematic timbering of a longwall face is of great importance. The props should be set in rows parallel to the general line of the working face; never staggered. The regular drawing of the back timber next the packs causes the underweight to settle forward on the face of the coal. The settlement of the overweight is regulated by the proportion of packwalls, and the manner of building them up. If the overweight settles too rapidly it

causes the underweight to bind, throws too much weight on the face, and crushes the timbers. If the overweight settles too slowly the progress of the underweight is retarded. The distance between the timbers, and the number of rows, will depend on the conditions of the seam, roof, floor, depth of cover, etc.

The coal is undercut by Sullivan's longwall machines,

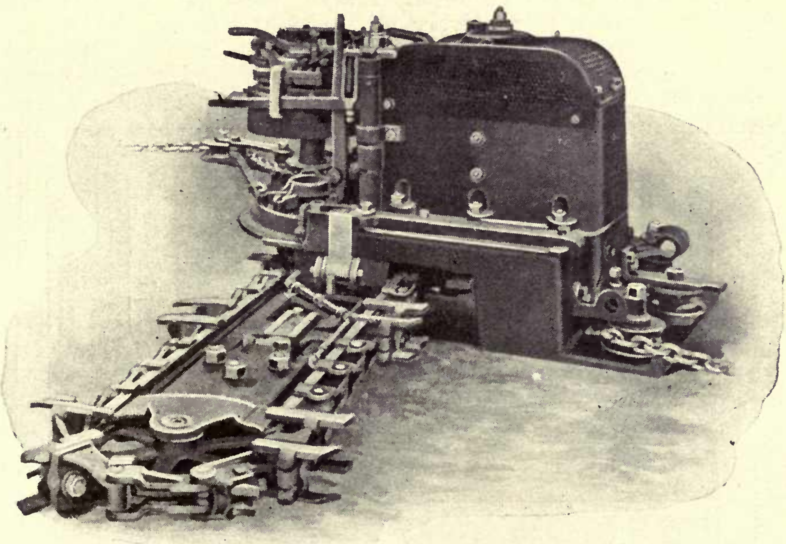


Fig 105—Sullivan Long Wall Machine.

of which there are four, driven by electricity; the motor takes 280 volts, 105 amp. and has 1225 revolutions per minute. This machine is similar to the Sullivan electric chain machine, the chief difference being that though the cutter-bar is swung into line with the machine when loading into a truck to flit to another place, while at work it is placed at right angles to the body of the machine. (Fig. 105.) The machine advances as the cutting proceeds, along a chain, placed parallel with the face, which is threaded through the machine and jacked at the ends. A driving sprocket engages with this chain, and so procures the forward motion, the machine sliding along the floor on a sheet steel shoe without the intervention of rails. This coal cutter uses about 15 b.h.p., and will cut 120 yards long, 5in. high, for a depth of 1½ yards, in an eight-hours' shift. It is worked by a driver, an assistant and a boy. The boy throws out the cuttings from the side of the machine, while the assistant cleans it away from under the

machine, and places some in the cut to support the coal. When the machine reaches the end of the face, it is placed on a truck and flitted back to commence a fresh cut.

Where the coal is thicker, and the pillar and bord method is used, the coal is found to be harder, and does not make so much slack; in fact, it has to be shot down. Carbonite is used for shooting down coal, and saxonite for shooting in rock. On either side of an intake heading is a return heading, known respectively as right and left. These are connected with the main heading by diagonally arranged cut-throughs, placed about $2\frac{1}{2}$ chains apart, and made 4 yards wide; those cut-throughs on opposite sides do not branch off from the same point, but alternately as shown in Fig. 106. The

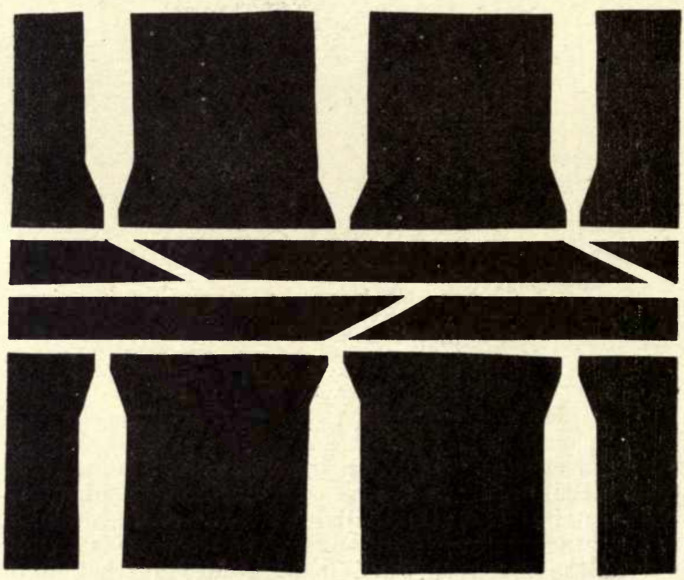


Fig. 106.—Welsh Bord System.

Welsh bord system is used, and these bords are turned off from both right and left headings, with necks 4 yards wide and 4 yards long. They are then widened out gradually on either side till 18 yards wide, and are then driven straight on. A track is laid along both sides of the bord, and any dirt is thrown in the middle. The bords are made indefinitely long. The coal pillars between the bords are 77 yards wide. Crosscuts are driven through the pillars at suitable intervals, which serve the purpose of roadways. Waiting till the bords are in to make these roadways, which shorten the

distance for conveying the coal, saves much original driving of narrow work. The longwall cutter is used in the bords with success; it doing better work than hand labour.

The endless-rope system of haulage is employed underground, driven by a semi-portable boiler and engine situated outside the mouth of the intake tunnel. The intake and return tunnels are about 50 yards apart, and are connected every 80 or 90 yards by stentons. The roadways are 12ft. wide and 8ft. high. Horses 11 to 14 hands high gather the skips from the working places. The skips hold about 15cwt. of coal; they have to be built low on account of the low roof. Four full skips or ten empties go to a set. They wait for a larger number of empties, so as to save time when clipping on, and also to save the wear of the rope where the clips fasten. Lang's lay rope is used, it being found most suitable for hauling purposes where drums and pulleys are comparatively small, and where the ropes are subject to severe side friction.

On arriving at daylight, the skips are weighed on an Avery's self-registering weighing machine, capable of weighing up to 30cwt. They are then run into a side tippler with a counter weight below, so as to right itself again after the coal has been discharged. The tippler is regulated by a brake, so as not to smash up the coal when dumping on to the screens. A side tippler has an advantage over an end tippler inasmuch as an empty skip need not pass out the same way as it entered, but can be pushed out the opposite end by a full skip; also a side tippler does not deposit the coal in such a small heap as an end tippler. The screen is stationary, but has a movable chute. The classes of coal produced are: 1st, Best screened, i.e., over $\frac{3}{4}$in.; 2nd, unscreened, with or without the duff taken out; 3rd, nuts between $\frac{1}{2}$in. and $\frac{3}{4}$in., and duff under $\frac{1}{2}$in. There is a self-acting incline from the mine to the level of the railway; the top portion has three rails, at the meeting there are four, while the bottom length has two.

The workshops are fitted with lathes, drilling machines and other necessary plant.

The ventilating current is produced by a 10ft. diameter Walker fan, into which the air passes from both sides. This fan is given 150 revolutions per minute and delivers air with a pressure of 1.3in. water. It is driven by a single cylinder engine provided with a Meyer's cut-off valve, by means of two manila ropes. The driving pulley has five grooves, and is geared 3 to 1. Both fan and engine were made by William Davies, of Wollongong. Provision is made for adding another engine to the other end of the crank disc, so that by turning the connecting and eccentric rods round, they can be connected to the duplicate engine when necessary to use it. The fan is situated

on one side of the return airway, and connected to it by a galvanised iron air drift, so that in case of an explosion this structure being light would be blown away, thus acting as a safety valve and saving the fan; and if destroyed, the drift could be easily and cheaply reconstructed.

Davis's water-gauge is used for reading the pressure of the air. As 1 cub. ft. of water at 62deg. Fahr. and under 30in. barometric pressure weighs 62.355lb., the pressure per square foot due to each inch in height equals $\frac{62.355}{12}$ or 5.196lb., generally taken as 5.2lb. The ordinary U-shaped gauge is difficult to read on account of the oscillations of the water columns; also if one limb is broken the gauge is useless. Davis's gauge consists of two straight pieces of boiler gauge glass sealed into a brass block in such a manner that they can be readily renewed. (Fig. 107.) A small hole in the

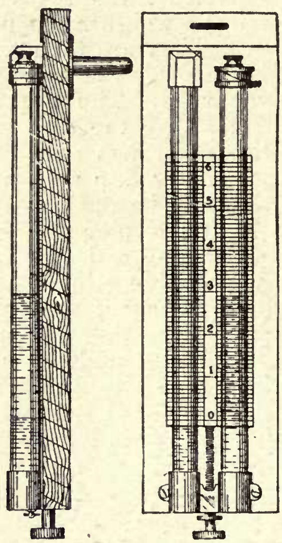


Fig. 107—Davis' Water Gauge.

brass block connects the two glasses, and in this is a thumb tap, with which one can minimise the oscillation of the water column due to the pulsation of the fan, and even stop the connection altogether, so that the height of the water column may be registered. As the pressure of a column is dependent solely on the vertical height, any irregularity in the section of the tube is immaterial. The scale behind the tubes is

divided into inches and decimals of an inch. the lines passing across the whole width of each tube. The whole scale is capable of being slid up and down to facilitate adjustment.

An electric three-throw pump is used, having a capacity of 4000 gallons per hour.

The electric plant consists of a generator of 340 amp. and 250 volts, with no load, and 280 volts with full load. It is used for coal cutters, pumping and lighting. This was the first colliery on the South Coast to apply electricity to coal-cutting machines. The generator is driven by a Fleming side-crank engine, made by the Harrisburg Foundry and Machine Works, Pennsylvania. Signalling is done by electricity generated by 10 Leclanche cells, and conveyed along 10 S.W.G. galvanised-iron wires.

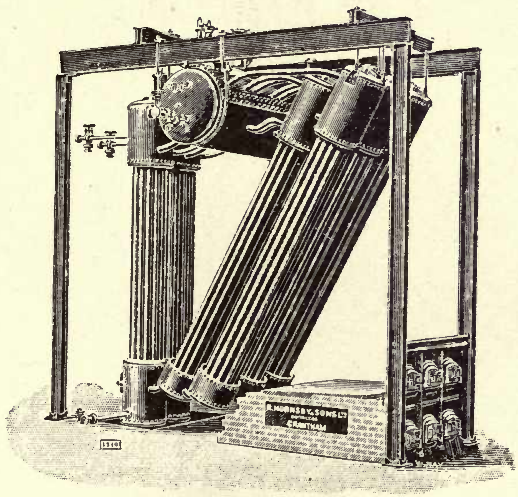


Fig. 108—Hornsby Upright Water Tube Boiler.

The boiler plant consists of a Hornsby and Sons tubular boiler, and a colonial multitubular boiler at the mine; there is also a Hornsby boiler at the coke works. The Hornsby is an upright water-tube boiler. (Fig. 108.) The tubes are assembled in nests; those nearest the fire-box being inclined, while those at the rear are vertical. A drum for holding water and steam is arranged at the top. The flame and hot gases from the fuel act directly on the tubes; the heating surface is large, and as the heat acts on small quantities of water in one place, steam can be raised rapidly. The constant rising of steam from the internal surface of the tubes creates a powerful circulation through the boiler, and tends to retard the deposi-

tion of sediment in the tubes. Such boilers are suitable for raising high pressure steam, and should an explosion take place it is not so likely to be disastrous as with a non-tubular boiler, for the part to give way will act as a relief to the rest. The several parts are comparatively small, light, and easily handled. The boiler is housed in brickwork, which also forms the firebox or chamber.

The conveyors used at this mine are the disc type of Jeffreys make, and are the first of their sort in Australia. One, 750ft. long, conveys slack from the slack bins at the

Fig. 109—Dragon Rope.

screens down hill to the disintegrator shed, at the rate of 60 tons per hour. This replaces the self-acting incline formerly used. The discs are 10in. in diameter, and are placed every three feet on the cable. The cable used—in this case 1in. in diameter—is the "Dragon brand," made specially by A. Leschen and Sons Rope Co. It is made up of six strands, each strand consisting of a triangular centre with two layers of five wires. Owing to the peculiar lay of the wires, as seen in Fig. 109, where different strands go in

opposite directions, rotating or twisting is prevented. The rope has a comparatively large wearing surface, the flattened shape of the strands bringing the greatest number of wires in each strand in contact with the grooves of the sheaves, thus greatly increasing the life of the rope.

Each range of coke ovens has a conveyor of its own, worked by electricity. The supports are above the ovens, and being subject to heat the whole apparatus is constructed of iron or steel. Each oven has two feed holes, and there is a valve in the bottom of the trough over each oven. When desired to fill an oven, the valve is opened and a duff-box with

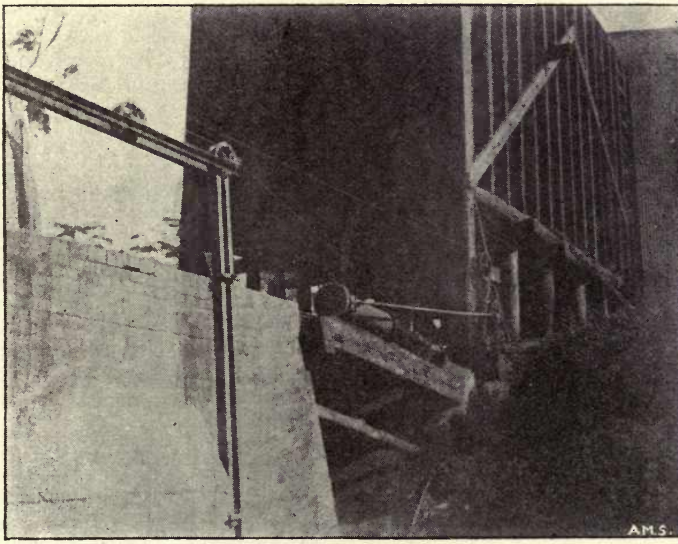


Fig. 110.—Hydraulic Ram for Working Doors of Ovens.

two spouts—one for each feed hole—which runs on rails is placed beneath. The spouts are arranged on a turntable, so that they can be moved out of the way of the oven chimneys when the canister is pushed from one place to another. When desired to fill the further range of ovens, all the valves in the trough above the first range are closed, in order that the duff can be dragged to the end, where it falls into a bin, having a capacity of 20 or 30 tons. So that an oven shall not be overcharged, a smaller hopper, which has the capacity of an oven charge, is filled, and its contents then run into the conveyor trough.

When the coke ovens now in course of construction are completed, this colliery will own 107, with an aggregate weekly capacity of 1200 tons. The ovens are charged twice a week, one charge being left in three days, the other four.

The coke ovens are rectangular in cross-section, with an arched roof. Each oven is 15ft. long, 6ft. 6in. wide at the ram end, and 6ft. 9in. wide at the exit end. The height from floor to crown of arch is 6ft. 4in. The ovens are 2ft. 2in. apart, and have 2ft. 2in. cover overhead. They are built of common brick lined with fire brick, the whole being well braced with buck-staves and tie rods. There is one stack having an inside area of 10 sq. ft. for each pair of ovens, con-

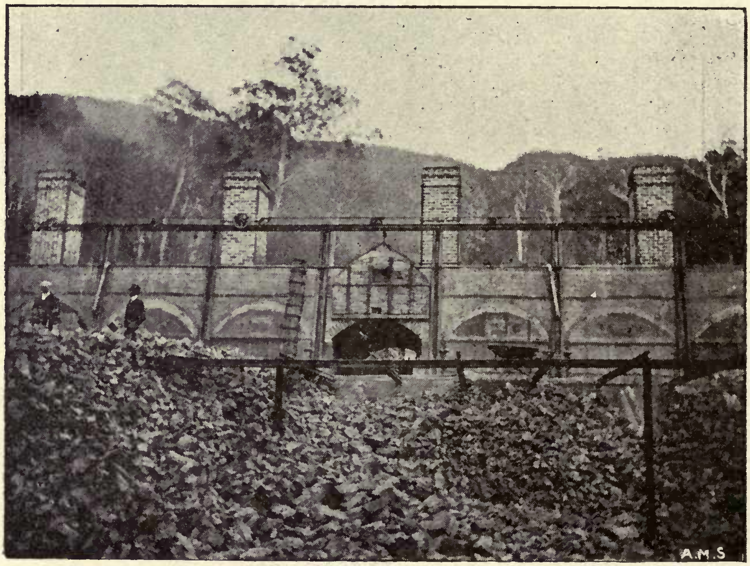


Fig. 111.—Coke Ovens.

nection being made by flues, each having its own damper. There are two circular feed holes in the crown of each oven, 20in. in diameter, the bricks for which are wedge shaped, both side and endways. The doors to the ovens consist of an iron frame built up inside with bricks, holes being left for air, which are stopped up temporarily when desired to restrict the admittance of air. The doors are raised and lowered by means of an hydraulic ram (Fig. 110), which moves a rope backwards and forwards as desired. A wire cord enables a man on the top of a bank of ovens to open or close the valve

that admits water to the ram; a clamp is fastened to the rope and connected with a door by chains. When the ram with a pulley at the end is forced out it draws the door up. (Fig. 111.) A water-pipe is laid alongside a bank of ovens, and a branch made for every four ovens, to which a hose is connected. The coke is quenched in the oven by inserting a long iron pipe attached to the hose at one end and closed at the other. Two rows of holes are drilled in the pipe in such a manner that the jets of water issuing from them diverge slightly. Water is only used on the coke outside the ovens when not sufficiently cooled inside. The ram used for pushing

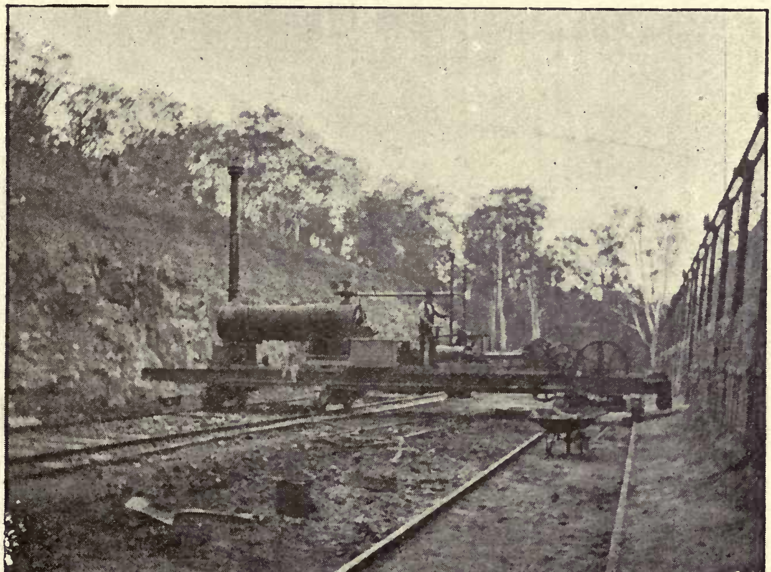


Fig. 112.—Coke Ram.

out the coke was made by W. Davies and Son, of Lilleshall Engineering Works, Wollongong. (Fig. 112.) It is driven by a duplex engine having 9in. diameter cylinders, and is treble purchase. The boiler is one of Ruston, Proctor, and Co's. The coke is pushed out on to rails over an incline alongside a railway line. (Fig. 113.) A charge consists of 6 tons of coal, and they reckon on obtaining two-thirds of the coal put in as coke.

The Austinmere and Bulli Pass Collieries.

These collieries are leased to the Southern Coal Miners' Association, who allow them to remain idle. They are both small locked in areas. Formerly so-called natural coke was supplied to the Sydney steam trams from the Bulli Pass mine. The Austinmere Colliery was worked years ago, and turned out a failure.

The Bulli Colliery.

The Bulli Colliery is about eight miles from Wollongong, in a northerly direction, and 1½ miles from the Bulli

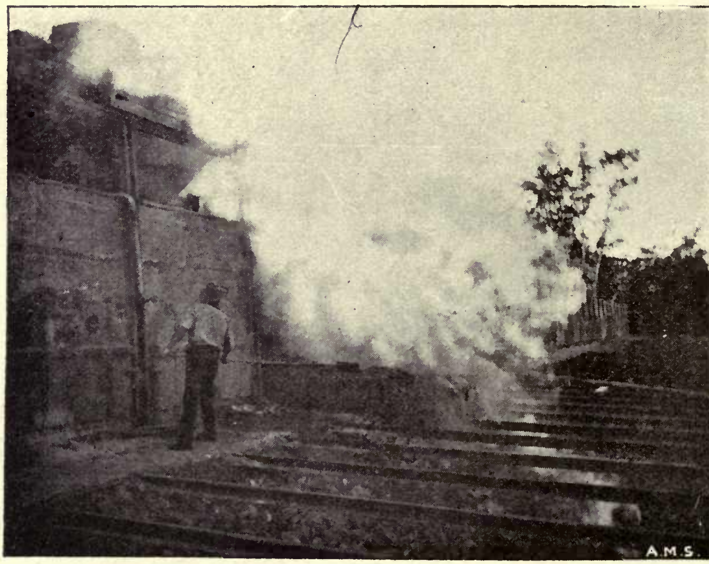


Fig. 113.—Coke being pushed out of Oven.

jetty. It belongs to the Bulli Coal Co. Ltd., and is controlled by Mr. Geo. Adams. The mine was commenced to be opened out in 1863. It is worked from tunnels, but like its neighbours it also has an air shaft.

Mention of the Bulli Colliery brings to the mind of the public the greatest colliery disaster that has ever taken place in Australia, bar one, viz., the Mount Kembla explosion, that took place 15 years later. About half-past two in the afternoon of 23rd March, 1887, an explosion took place, followed a few seconds later by a second one of less intensity. These resulted in the death of 81 persons. Apparently few if any

were killed by the actual explosion itself, for most of them died while in the act of escaping from the effects of poisonous gases, as indicated by the positions and conditions of the corpses. The total annihilation of life was due to the small area opened up in the district where the explosion took place, no wastes existing wherein the force of the explosion could expend itself, it being confined to the narrow strip of working where the men were actually engaged.

According to the findings of the Royal Commission which was appointed to inquire into this disaster, the accident was caused by an explosion of light carburetted hydrogen gas that had accumulated at the face or between the face and the last stenton of No. 2 heading, in the Hill End district, and that the immediate cause of the explosion was, in all probability, the flame from an overcharged shot that had apparently been fired in the coal on the top of a roll in the face of No. 2 heading; also that the explosion was intensified, and the force increased to distant parts of the district, by the presence in the mine air of coal dust in a minute state of division.

Fire-damp was first seen in the Hill End district between eighteen months and two years prior to the explosion, having been discovered when crossing a dyke in the main heading incline plane, and since then it had been reported in small quantities. Fire-damp is by no means uncommon in the neighbourhood of dykes, where the igneous rocks often burn the coal in its neighbourhood to a cinder, and in others by driving off some of the volatile hydrocarbons leave behind so-called natural coke. There is a good deal of both cinder and natural coke at Bulli. A considerable area of the Bulli Colliery is subject to "rolls." These are rises in the floor, which have a greater length than breadth; individually, the same roll is seldom traced for any great length, but where one ends another may commence. Sometimes they occur so frequently that a roll may serve as a pillar between each bord. Anyhow, they seriously interfere with the laying out and winning of that part of a colliery in which they occur. These disturbances are solely confined to the horizon of the upper or seven-foot seam; in the four-foot seam below, these irregularities have not been found. Also the roof of the upper seam is slightly, if at all, affected. As a rule these irregularities do not cut off the whole thickness of the coal seam. The mine was ventilated by means of a furnace, but this does not appear to have had anything to do with the explosion. The colliery is a dry one, the atmosphere is warm, and the coal is friable and easily pulverised, so that during work the air becomes charged with dust. The main road used to be watered, but not the headings or working-places. It is well known that most dust is made in the latter, where

men and horses are constantly trampling coal underfoot. In the main haulage-ways the dust is not so disturbed. Then again, the top dust, which is very fine, and settles on the top of timbers, is purer than that lying on the ground, which is more or less mixed up with rock dust—it is not so readily watered, but is easily reached by flame. Also porous dust is more dangerous than dense dust. The enormous surface presented by coal in a minute state of division, to the action of flame, induces instantaneous combustion, and distils off gas. But beside chemical properties, it would seem that coal dust, anyhow at the inception of a coal mine explosion in which it takes part, may act catalytically. The reason for catalytic phenomena is somewhat obscure, for certain effects are brought about by the mere presence of a substance which itself undergoes no perceptible change. It has been shown by experiment that an inert substance, such as magnesia, when finely pulverised and suspended in air will assist the explosion of an admixture of fire-damp and air. With regard to watering coal dust, it is necessary that the dust be properly moistened to be effective. We all know how a drop of water falling on dust gets coated with the fine particles and rolls about on the top of it, also if just sprinkled on the top of the dust a moist crust may be formed, but the first footstep stirs up the dust below it again. Very little dampness is necessary to prevent dust from igniting so long as the whole of the available dust is damp. In this mine we had the two main sources of colliery explosions—fire-damp and coal dust—moreover, the atmosphere was warm and dry. The heading in which the explosion occurred rose as the miners advanced, yet bratticing was not used in the space between the last stenton and the face of the headway to drive out foul air, consequently the lighter gas would tend to accumulate at the face, where the air being stagnant would serve as a reservoir for gas. One would naturally expect under the circumstances that extra precautions would have been taken to avoid accidents, but instead there appears to have been carelessness, and a total disregard of the most ordinary precautions by those chiefly concerned. Safety-lamps were used in the danger zone, presumably as a talisman, for it was the old-fashioned Davy, with an insecure lock that was not always fastened, and shots were sometimes fired by lighting touch-paper by tilting the safety lamp so that the flame could ignite the touch-paper through the gauze; not only this, but the fuse was sometimes lit by the flame of a lucifer match. That men were allowed to carry lucifer matches, and use tobacco in a district where fire-damp was given off, shows lax discipline, and the wonder is that an accident did not occur from causes other than an overcharged shot. It is strange how some people will not use a little forethought, but insist on experiencing everything

themselves and how familiarity with danger breeds contempt, more especially in cases where serious consequences have not been experienced by the individual. The shot holes appear to have been generally tamped with small coal or dust, not even properly damped. This, as is well known, elongates the flame produced by blasting, especially in the case of blown out shots, and as the miners frequently neglected to thoroughly undercut the coal before firing a shot, they practically blasted coal out of the solid, so that either a heavier charge had to be used to break down the coal, or the tamping, offering less resistance, was blown out. The stump left of the hole that is supposed to have caused this great loss of life showed that the charge did not do the work expected of it. The Commissioners consider that the disaster was largely due to the absence of proper precautions in thoroughly undercutting the coal and preparing shots, also probably to an error of judgment in gauging the necessary amount of explosive required. The danger of coal dust is now so well recognised that in properly appointed mines when necessary to fire several shots in a dusty place, they are either fired simultaneously, or sufficient time is allowed between shots for the dust to settle or be carried away by the ventilating current.

The heat generated by exploding gun powder in a confined space, such as a drill hole, is greater than that generated in the retorts of gas works: the temperature in each particular case varying with the quantity of powder in the charge, and the duration of the explosion. The amount of energy developed by an explosive substance is often overlooked. A single pound weight of ordinary black powder when exploded develops 360 foot tons. A pound of ordinary fine bituminous coal suspended in the air, when converted into gas, as in the case of a mine explosion, develops 4600 foot tons. Of the gases, a pound of methane (23.4 cub. ft. at 60 degrees F. and 29.925 bar. press.), develops in explosion 9146 foot tons: a pound of carbon-monoxide (13.5 cub. ft.), 1682 foot tons, and one pound of olefiant gas, 8302 foot tons.

The distribution of dust in a mine is more general than gas, so a dust explosion tends to travel further, but having to first convert the dust into carbon-monoxide, and then into carbon-dioxide, the explosion is not so sudden. Carbon-monoxide is also one of the gases given off by the explosion of gunpowder. A trace of this gas in a dust-laden atmosphere is as explosive as a much larger quantity of firedamp, and, what is more, it is ignited at a much lower temperature than a mixture of marsh gas and air. It has been demonstrated that a blown out shot is capable of igniting mixtures of coal dust, marsh gas and carbon-monoxide with air. A small local explosion, which in itself would be of little moment, may

become vastly extended by the presence of coal dust, and it makes a very small proportion of fire damp or carbon-monoxide explosive that would otherwise be harmless. Speaking generally, a gas explosion develops centres of greatest violence in those localities where gas issues from the strata or tends to accumulate, and the centres of violence are more pronounced than in a dust explosion. A dust explosion feeds on material scattered in its path, and follows those passages that promise the largest supply of food in the form of dust and oxygen. One of the characteristics of a dust explosion is the persistence with which it seeks the intake, and advances against the current in its search for air. The flame never enters far in the direction of the return air, because it is extinguished by the products of its own combustion: gas, on the other hand, is most likely to be found in the return air ways. At the time of the Bulli disaster. the return air was made to ventilate other headings instead of allowing it to pass over the main tunnel direct to the return air way. Secondary or back explosions are generally attributed to combustible gases developed from highly heated coal dust, which remains unburnt, also to gas sucked out of the faces of the coal by the partial vacuum resulting from the explosion, or liberated by falls of roof. As soon as fresh air rushes in, it forms an explosive mixture with these gases, and a second explosion is liable to occur. It is known that dust explosions have taken place in certain flour mills, where, so far as one is aware, there are not explosive gases, therefore it is quite possible that a pure dust explosion may occur in certain coal mines: but, under existing conditions, it is doubtful whether a pure dust or pure gas explosion ever takes place in a colliery, except on a minor scale, for one tends to create the other.

The days of this colliery are nearly numbered, most of the coal that is won being taken from pillars. The coal in this colliery is much disturbed by volcanic intrusions, which occur as dykes and laccolites. The hot rock has driven off much of the volatile hydrocarbons, leaving a so-called natural coke, which finds a limited market.

The main surface buildings are located at Old Bulli, and from here the seam is reached by two tunnels. About a mile further north is another tunnel, known as No. 3. There is no rope haulage to the surface from this tunnel, the skips being drawn out by horses. At Old Bulli the rails of each tunnel have a different gauge, so where the lines have a common course at the surface the track is laid with three rails. The skips are run into end kick-ups, which empty their contents on to stationary screens. So that two skips shall not turn off towards the same kick-up at one time a foot point is pushed

across the turn off and parallel with the main line (Fig. 114). Underground at Old Bulli the different districts are served by the main and tail rope system of haulage.

Railway trucks are filled at the screens and drawn to and from the brow of the self-acting incline by an endless rope, to which they are attached by a small screw clip. One hopper truck or two black trucks pass up and down the incline at a time. The trucks are prevented from running down the in-

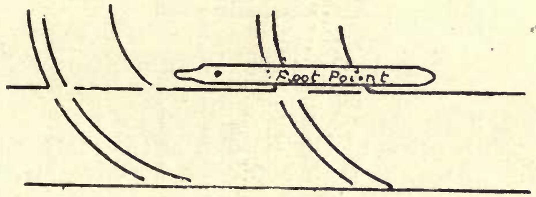


Fig. 114.—Foot Point.

cline before the man in charge wishes, by means of block stops, but there are no throw-off switches in case of accident. The line consists of four rails for the top and middle sections, and two rails for the lower section. The ropes are wound round two drums mounted on one shaft; one rope goes over, and the other under. The brakesman controls the speed by means of a lever. At the lower end, the line for the full truck overlaps that of the empties on the flat, so when a full truck starts from the top it first has the slack of the rope only to take up, and then to haul the empty a short distance on nearly

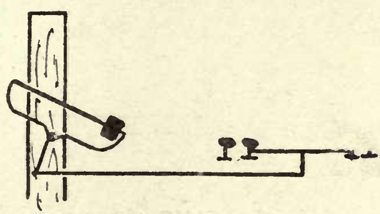


Fig. 115.—Sliding Weight.

horizontal ground before having to draw it up the incline. The No. 3 tunnel is also served by a self-acting incline, but this has three rails for the top portion, four rails in the middle where the sets pass, and two rails at the bottom. Where the four rails merge into two, an automatic point with a sliding weight (Fig. 115) is used, while at the bottom, where the two rails branch into four, for the full and empties, another automatic point, with a fixed weight, is employed (Fig. 116). At the bottom of the incline, the full skips run along an upper

line to the top of coal hoppers, while the empties run down a lower line automatically (Fig. 117). The two ropes for this incline are wound round one drum, divided in the centre by a flange. The speed is regulated in the usual way by hand

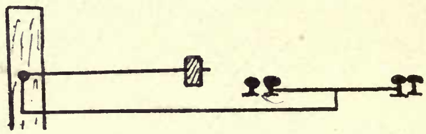


Fig. 116.—Fixed Weight.

brakes. Six mine skips are sent down at a time. Coal is filled from the hoppers at the bottom of the incline into railway trucks. These can then be drawn by locomotives, either to the main South Coast line or to the company's jetty: the

Fig. 117.—Foot of Incline.

latter is now in course of being rebuilt, it having unfortunately been destroyed by bad weather.

In connection with this colliery, there is a battery of 39 coke ovens. These ovens are 20ft. long, 4ft. wide at one end, and 4ft. 6in. wide at the exit end. The small coal is

first passed over an inclined shaking screen made of punched sheet iron, having a trough attached to it below to catch the slack. The nuts are generally shipped, while the slack passes through a Carr's disintegrator prior to being coked. The slack makes better coke than the nuts, as the latter frequently contains pieces of stone which add to the ash. The coal dust is elevated by a bucket elevator, to a hopper, from which it is fed into cannisters that run along the top of the ovens into which it is charged. The coke is pushed out of the ovens by means of a hydraulic ram. The water is supplied to this ram through mains from a four-throw vertical plunger pump. When the water is not required by the ram it passes

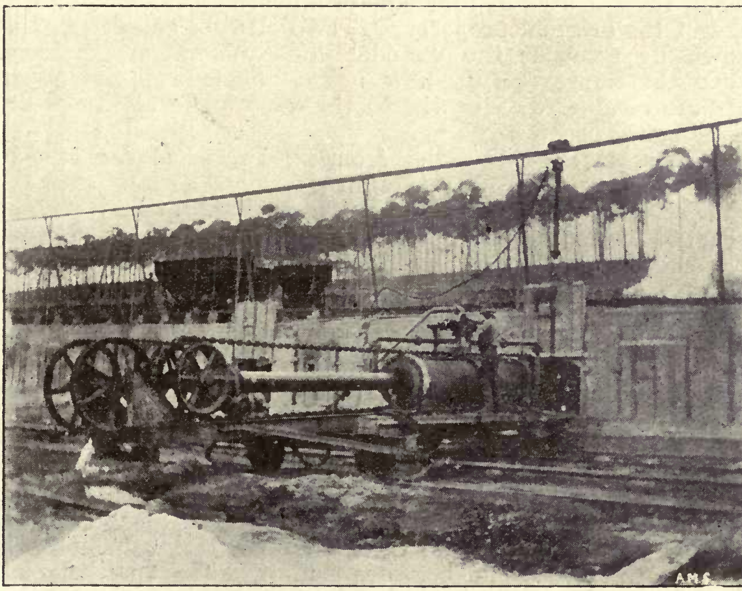


Fig. 118.—Hydraulic Rams.

to an overhead tank. As the ram changes its position from one oven to another, it is connected to another part of the main water pipe by the hose. The ram is caused to travel along its three rail track by an endless rope (put in motion by gearing from the pump) which circulates beneath it, and to which it is attached by a clip when desired. The doors of the ovens are raised by small vertical hydraulic rams (Fig. 118), suspended from an overhead rail, and when raised, the doors are hung from their lugs by hooks.

South Bulli and Bellambi Collieries.

These two collieries are now owned by the Belambi Coal Company Limited, of Melbourne, and are managed by Mr. A. E. O. Sellers, who has been in charge for the past seven years. The South Bulli colliery was started by Messrs. Taylor and Walker, in 1862. After driving a tunnel for five or six chains, they came across a basaltic dyke, which had partly cindered the coal next to it; this so disheartened them that they abandoned mining operations. The property was next taken up by Messrs. Saywell and Wilson, about 1885 or 1886, and they continued to work it till 1890, when the late Mr. Ebenezer Vickery bought it. He in turn sold it to the present holders, who, at that time, owned the Bellambi mine. In May, 1908, a further area of four square miles was taken up at the back of the original property. The Bellambi colliery is also known by some as the "Model' or "Woonona" colliery. When the improvements now being effected at the South Bulli are completed, this will be the most modernised colliery on the south coast.

The seam worked varies from five up to eleven feet in thickness, averaging about eight feet. The roof-shale is about twelve feet thick, and the floor-shale eight feet. The nature of the roof and floor rocks appears to have had a decided influence on the formation of the rolls, which in turn have an important bearing on the laying out of the mine. The general direction of these rolls is N.W. and S.E. The same roll has been traced for over half a mile, and may go still further; others die out and commence again. They may run parallel, but also merge one into the other. They occur at irregular distances apart, and vary in height and width, as a rule the rolls are more numerous and defined near the crop. The coal is the most distrubed, soft coal being bent more than the hard; the lower shale is also affected, and the roof is sometimes slightly bent, the coal may even be forced into it. The lower shale is fairly uniform, but the upper shale varies in thickness, and becomes shallower towards the west. The rolls are highest where the shales are thickest; it is also noticed that the thinner the coal, the shallower the rolls. These rolls are not found in the northern part of the field. At Clifton they have a sandstone roof, which is not so yielding as shale, whilst at Helensburgh, where they have shale, there is a much greater depth of cover than at Bellambi. When the rolls are long and well defined, they show joints, known as "grey backs," which may dip in the same or opposite directions, at varying angles. The junction between the coal and the lower shale at a roll often has a black polished skin like a slicken-slide. The rolls were formed earlier than the dykes, which break up through them, while the faults are more

recent than the dykes. It would appear that these rolls are purely local in their origin, and from facts collected in connection with them, it would seem that the shales forming the floor had swollen, possibly due to an access of water, and in order to re-adjust itself to the altered conditions, formed corrugations and contorted the coal, which, being soft and fairly thick, took up the brunt of the force, transmitting but little to the roof-shale. Gases may also have assisted in developing the pressure.

Four tunnels are used at the South Bulli colliery; coal is hauled out of two, while the other two are used for air and travelling ways. At a point a mile and a half from daylight, four intakes come together, and from there onward four roadways are carried forward. The haulage roads are twelve feet wide and 7ft. 6in. to 8ft. high. Parallel roads are twenty yards apart from centre to centre, and cut-throughs are made between them about every forty yards. There is a solid barrier of coal 55 yards wide, between the haulage ways and the working places, which are only broken through every 20 chains for side roads. These side drifts are driven in such a direction that they cross the stone rolls at right angles in order that the bords driven off them can be put in parallel to the stone rolls. As the roof is not good enough for ten yard bords to justify the extra expense of timbering, the bords are made eight yards wide. When extracting the pillars, a skirting is first taken out parallel to the bord and rock roll, and then the coal on the rock roll itself is mined. For blasting the softer parts of the seam, bobbinite is used; for ordinary pick ground, monobel; while for heavy shots, e.g., over coal cutter holing, kolax is used. Saxonite is employed for rock blasting.

A new tunnel is being driven in the four-foot seam below the Bulli seam, underneath the old workings; this will save straightening and repairing the old haulage ways, and will enable the coal of the pillars overhead to be won in the most economical manner.

The Bellambi workings are connected with those of the South Bulli, but they have two tunnels of their own. The haulage is done by the main and tail rope system, and steam power only is used at this mine.

Steam is generated at the power house in Lancashire boilers, the ashes from which fall through a plate in front to skips below, which convey them to the waste heap. Feed-water heaters are employed at this colliery; that for the haulage engine raises the feed-water to 170deg. F., while that at the fan engine raises the temperature of the water to 206deg. F.

The old generating plant for 105 k.w. is one of the General Electric Company's, of New York, 60 cycle alterna-

tor, giving 2300 volts, which is direct coupled to a Harrisburg engine. A Tyrrell regulator is used to regulate the voltage during the varying loads of the three phase alternator. The new plant of 350 k.w. consists of a Siemen's alternator driven by a Bellis and Morcom engine. This will give sufficient power to work all the haulage, both underground and on the surface.

The cable, of which there are about 14,000 feet, and was supplied by Siemens Bros., of London, is three phase, paper insulated, jute compounded, lead covered, water resisting, and steel armoured to render it pick proof, and covered externally with rust resisting preservative. This cable is laid in a trench cut nine inches deep at one side of the road, partly in the return air way, which is preferred if not too crooked, and partly in the intake. As a further protection from falls of roof, when the water main and cable are in the same roadway, the former is placed above the latter. When laid in a heading where men travel, a white line is painted on the roof above it, and calico notices are fixed every fifty or sixty yards, drawing the miners' attention to it. The current is conveyed into the mine at 2300 volts, but this is stepped down by static transformers to 220 volts before use. To connect the main secondary direct current cable with the trailing cable of the coal cutter, Mayor and Coulson's joint end boxes are used. There are gas-tight boxes containing fuses and switch.

The three main cables pass down the air shaft and are connected to others below in boxes. If anything goes wrong with a cable in the shaft it can be detached at the box and hauled to the surface for repairs. A Siemens' lightning arrester is fixed at the top of this shaft.

In the mine there is a motor generator set of 59 k.w. for transforming the alternating current for the direct current motor of the coal cutting plant. At present, a Goodman's electric coal cutter is used for working the harder coal, but the plant is capable of driving five of these chain breast machines. The chain bar of this machine is 6ft. long, and the cutting width of the head 3ft. 6in. The machine will cut in that depth and return in $3\frac{1}{4}$ minutes. The direct current motor of the machine, together with its switch, is enclosed in an ironclad case, which is absolutely gas proof, the starting resistance being manipulated by an outside handle.

One and a half miles in from the side of the hill is located a 100h.p. motor, three phase enclosed Siemens, belted to a single ended Reavell air compressor with four cylinders, which runs at 253 revolutions per minute, and is capable of compressing 358 cubic feet free air per minute to 70lb. per square inch. It is provided with a relief

valve, unloading device, and an air filter to clarify the air from dust. This air filter consists of a cast-iron box, in which are placed two gauze trays of very fine mesh, the space between being filled with cotton wool. A branch pipe taken from the water main to the locality of the compressor has a spray attached to it; in this way the air drawn into the compressor is kept moist and cool, so as to lessen any chance of an explosion taking place, due to the heat developed by compression in the presence of coal dust. The Reavell compressor is a different type to that generally seen at mines, and much more compact, as will be noticed by referring to Fig. 119. It has four cylinders (A) arranged radially in a circular shaped casing (B), each cylinder has a piston (C), and the connecting rods (D) are all driven by a crank-pin in common. Each cylinder is a separate single acting compressor, and as they all deliver into one common delivery passage (E), the supply of air is practically continuous. As the machine is driven in the same direction all the time, it can be run at a relatively high speed, and is, therefore, very suitable for electric motive power. The cylinders pass through an annular water-jacket (F), which serves to keep them cool. Water is circulated through this chamber by a small centrifugal pump. A small balance or pilot piston (G) is provided to minimise the side thrust on the piston. There are no suction valves, the cylinders are filled with air at atmospheric pressure at each stroke, instead of at a reduced pressure due to the resistance of valve springs, thus increasing the volumetric efficiency. The free air passes into the casing through the passage (H). The piston has two ports arranged on the top to correspond with two sets of ports in the head of each connecting rod; one set is directly on the top, the other a little on one side. The delivery valves fitted to the outer end of each cylinder are shown at (I): the number of such valves used for each cylinder varies with the size of the machine. Following the course of the piston of one cylinder commencing with the suction stroke, there is no partial vacuum caused at the commencement of the stroke, for the little air left in the cylinder, being under compression, will expand as soon as it has a chance. When the piston has moved so far down that the hollow head of the connecting rod comes abreast of the two ports (J) in the lower part of the cylinder, free air is admitted to the cylinder through the ports of the connecting rod and piston: at the bottom of the stroke the piston covers the ports in the cylinder and the air enters direct from the inner chamber. On the compression stroke no air can escape through the connecting rod head, for this is now turned in the direction where there is no port to correspond to that in the piston, while at the end of the

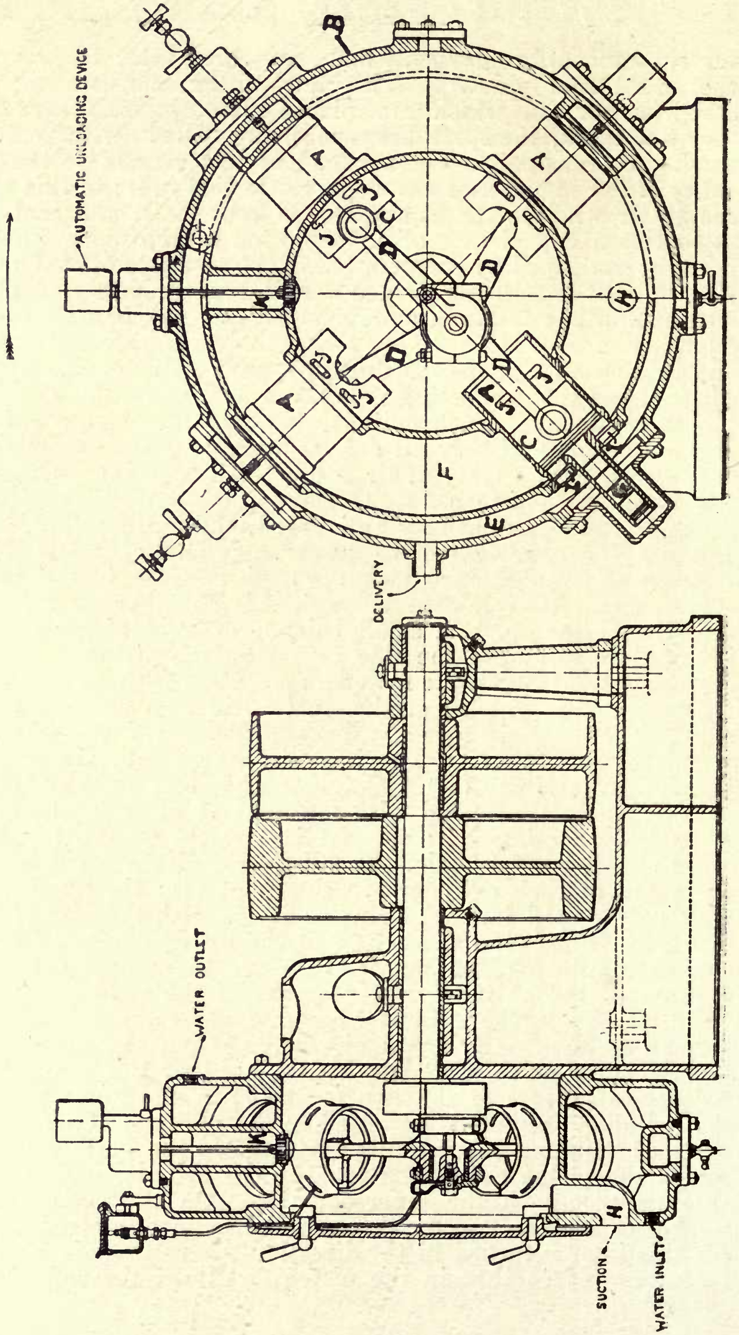


Fig. 119.—Reavell Air Compressor.

stroke, when the top set of ports do coincide with the piston ports, no escape can take place because the connecting rod head fits tightly inside the cylinder.

This quadruplex compressor is very simple in construction, and is readily taken to pieces. The automatic unloading device shown at (K) is a bye-pass valve, which forms a connection between the delivery and suction side of the compressor.

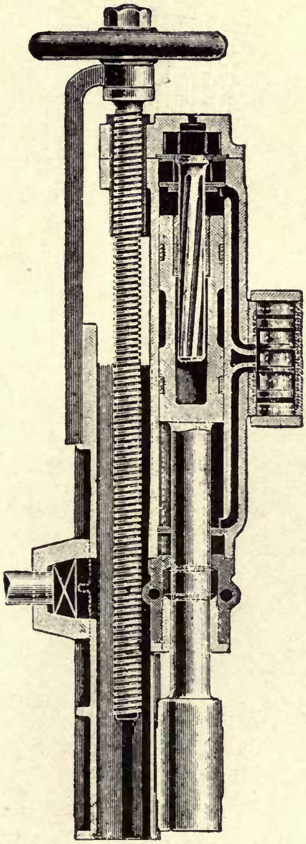


Fig. 120.—Little Hardy Coal Cutter.

It is automatically controlled, so that when the air pressure reaches the desired limit the bye-pass valve opens, thus relieving the motor of the load. As soon as the pressure falls to a predetermined limit, this valve closes, and the compressor commences to deliver air again. The air receiver between the compressor and the air drills is 10ft. long by 3ft. diameter.

The Reavell compressor is provided to supply air for working Little Hardy Coal Cutters, and being located in the mine near the pneumatic drills, a great length of piping is saved. These cutters are of the rock drill type, but are specially fitted for coal mining work, and can be used for holing and shearing in hard coal headings. The internal construction of the machine will be seen from Fig. 120 to be a reciprocating air

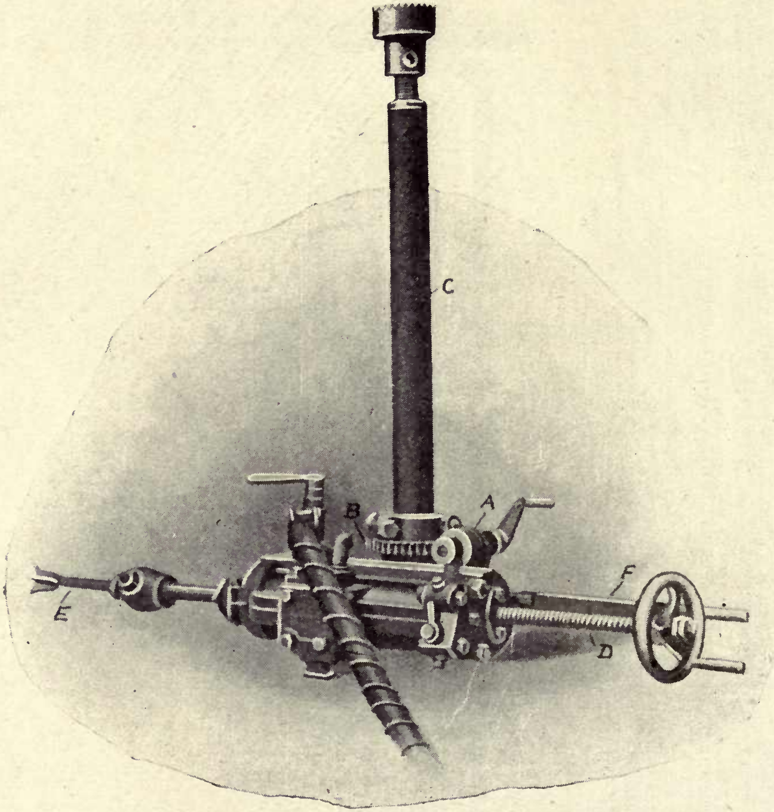


Fig. 121.—Little Hardy fixed for Undercutting.

drill, the chief feature of which is the valve, which is thrown over at the maximum attainable speed by live air at full pressure, which acts on the whole surface of one end of the valve piston, while the opposite end is open to complete exhaust. With a pressure of 45lb., 450 to 500 blows per minute are struck, while with 60lb. pressure from 650 to 700 blows per minute are obtained. The valve is circular in cross section,

and is free to assume any position in the valve chamber; there are no tappets, guides or other mechanical connections to affect its action. The coal cutter is fixed in position and held up to its work by means of a solid drawn steel tube provided with a powerful jackscrew, toothed head and foot, see Fig. 121, which shows a side view of the Little Hardy fixed for undercutting. The machine is seated in a cone cup forming part of a hinged clamp attached loosely to the column. This clamp carries a worm (A), the teeth of which mesh with those of a worm-wheel (B), bolted rigidly on the column (C). By turning the worm handle, the coal cutter is caused to move round the column, the forward movement into the coal is obtained by the feed-screw (D) at the back of the machine. The cutter bar (E) generally has four prongs. While working, the machine is swung to right and left by the worm gear, and fed forward as necessary; in this way an arc-shaped channel is cut, increasing in depth and width as each successive length of cutter bar is inserted in the machine. As soon as the desired depth is reached, the operator works in gradually decreasing sweeps on right and left hand sides, until the channel is of uniform depth at every point, and perfectly square at the sides and corners, using the longer cutter bars where necessary. If, after the undercutting is finished, it is desired to shear or nick the coal, the machine is fixed near the centre of the column and is worked by a lever (F) from top to bottom, though it can be worked by the worm gear if desired. The coal cutter proper weighs 150lb., and the total weight of a complete apparatus is under 3cwt., including column gearing, cutter-bars, air-drill, etc. The air pressure should be from 45lb. to 60lb. per square inch. The machine can be flitted from one place to another by a man and a boy.

At one time the colliery was drained by a Moore hydraulic pump, whereby motion was conveyed from the surface to the pumps below by means of water columns caused to oscillate by hydraulic rams which were steam driven. This system gave place, in 1904, to an electrically driven three-throw single acting pump, with 8in. cylinders and 12in. stroke, on account of the greater flexibility of the electric system. The pump, and a 30 h.p. induction motor for driving it, are located in a chamber underground, one and a half miles from daylight. The motor, which is the short circuit rotor type, with compensating starter, revolves 514 times per minute, and is connected with the pump by belting. The pump shaft revolves 45 times per minute, and raises 18,000 gallons per hour against a head of 270ft., inclusive of pipe friction. The pump was designed at the mine, and manufactured by Goninan, of Wickham, N.S.W.

A small generator set of 8 h.p. capacity is used for running lights. The travelling ways are lighted by means of incandescent lamps for the first few hundred feet from daylight, so as to give the men a chance to get their underground eyesight more rapidly. Electric lamps are also used at the flats. The safety lamps carried by the miners are the Thomas and Williams Cambrian type, fitted with electric ignition apparatus. Re-lighting stations are provided below at suitable points. The batteries used for re-lighting the lamps are accumulator batteries charged from a dynamo, and they are kept in a wooden box enclosed in a brick chamber. The glass of the Cambrian lamp is slightly greater in diameter than that of some other makes, and does not get so hot. The gauze, instead of being doubled, simply has a cap over the top, (which is the part that first gets burnt out); this enables air to have access to the lamp easier, and in consequence it burns better. This is just as safe as the double gauze, for as soon as the gauze shows signs of damage. it is discarded, the cap in the meanwhile acting as an extra precaution. The gauzes are more particularly examined twice a week. The lamp can be cleaned by taking but two parts off. i.e., the oil vessel and the shield, leaving the rings, glass and gauze undisturbed, so there is less likelihood of the parts being mislaid, and time is saved.

Formerly a Waddle fan was used at South Bulli, and a Schiele fan having a capacity of 50,000 cub. ft. per minute at 1½in. water gauge at Bellambi, but now the ventilation is carried out with the assistance of a Walker's patent indestructible fan, 26ft. in diameter and 8ft. wide. the air entering into it from both sides. This is the largest fan in Australia, and is driven by a compound engine capable of developing 550 h.p. under non-condensing conditions. The plant is guaranteed to produce 450,000 cubic feet of air per minute at a pressure of 5½in. water gauge. At present the fan only revolves 70 revolutions, and passes 250,000 cub. feet of air per minute, that being sufficient to serve both mines. The bearings of the fan are lubricated with heavy oil. but water pipes are arranged in case it should be necessary to keep them cool. The fan engine was made by Walker Bros.. of Wigan, England. The high pressure cylinder is 23in. in diameter, and the low pressure cylinder 38in. diameter, the stroke being 4ft. 6in. At present it runs at about 40 revolutions per minute. It is provided with Meyer's adjustable valves. The steam valves are so arranged that either engine can be used independently of the other.

In the important air-ways sometimes three doors are used instead of two for an air-lock, as an extra precaution.

At South Bulli the endless system of rope haulage is in vogue. Originally a single continuous rope passed through

the different districts, but now a separate rope is used for each district, driven by its own motor. The advantages of this change are obvious; the waste of power in circulating a rope where it is not required is saved, so a smaller driving engine will do; the longer a rope the heavier and stronger it must be, the elasticity increases with the length of the rope, and the jerks are worse with a heavy than a light rope, thus making the skips travel unsteadily; there are more bends in one continuous rope than when a series of ropes are used, and if a breakage occurs when the single rope method is employed, the whole system is stopped, whereas if a district rope breaks, there is only a local stoppage. With separate ropes, when the main rope shows signs of wear, it may be put to work in a district where the demands on it are not so great; in this way the life of a rope may be extended. As electric motors are used for the different districts, when one is not in use, the electricity which would otherwise be consumed can be used for other purposes, or the load on the engine at the surface may be lightened.

Forty chains in from daylight is a 20 h.p. haulage motor of the slip-ring rotor type, with a tramway style of controller and outside resistance, for a branch line 960 yards long. One mile thirty chains from daylight is a 75 h.p. motor, having 720 revolutions per minute, also of the slip-ring rotor type, with external resistance and tramway type of starter. This circulates a rope four and a half miles total length, which is being extended all the time, and is capable of working another two miles of rope or one mile of line. Both these plants get their first reduction by belting; any further reduction is obtained by spur gearing. All the haulage gear was built up at the company's shops.

Where tommy-dodds are used at curves, and the line has an incline, those on the up-track are connected by a cap, which allow the pulleys a certain amount of play, at the same time stiffening them.

The clips that connect the skips with the rope are the ordinary screw pattern employed on the South Coast. They are made of crucible seel.

The coal skips, as they come out of the mine, are now run into tipplers similar to those employed at the Metropolitan Colliery, Helensburgh. The on-coming full skip pushes the empty one off, which then runs down an inclined track at the bottom of which it bumps against an obstruction, and the recoil shunts it on to a branch which leads to the mouth of a tunnel, where it is clipped on to an endless rope.

A three-skip tippler (Fig. 122) is now in course of erection, which will be power-driven to ensure regular speed of rotation. The tippler will be started and stopped auto-

matically by the skips entering and leaving it, but will also be under the control of a brakesman. This tippler, which is 12ft. 3in. in diameter, will not tip more coal per hour than three of the present sort, but will do so at a slower speed, with less damage to the coal.

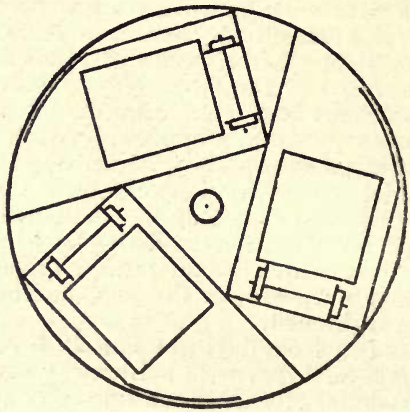


Fig. 122.—Tippler.

There are two classes of trucks employed to convey coal to the jetty, viz., the "black truck" and the "hopper truck." The former gets its name from the fact that it is tarred, in contradistinction to the hopper truck, which is painted red. The black truck is sometimes known as "Hudson's," after Hudson Bros., of the Clyde engineering works, who used to make them. They are box-shaped (Fig. 123), and have an end door. This door swings from the top, and is kept closed by two latches at the bottom; these latches can be opened, either by hand, or automatically by a cam-shaped lever which is pushed up by a bar on the tipplers, thereby releasing the door. It was found that cast-steel wheels did not last so well as built up wheels, which are now used. In the recently made trucks the axles are lubricated by a pad placed in the axle box, as seen in the figure, the protecting slide of which is shown withdrawn. The brakes are worked by a hand lever from one side.

The hopper-shaped trucks are constructed to empty into shoots over which they run, the coal dropping through bottom gates. It is therefore not necessary that the body should have lugs by which it can be lifted, as when loading with cranes.

The company owns six locomotives, four of which are in use at a time, the other two being held in reserve.

On the surface at South Bulli the gravity plane has a capacity of 1700 tons every nine hours. The hopper trucks are run singly on the incline; the black trucks two in a set. The open rope is capped by threading it through a socket, untwisting the strands, turning the wires back on themselves, and drawing back into the socket as far as it will go. The narrow end is then stopped up with clay, and an alloy made up of 60 per cent. lead, 30 per cent. tin, 9 per cent, antimony, and 1 per

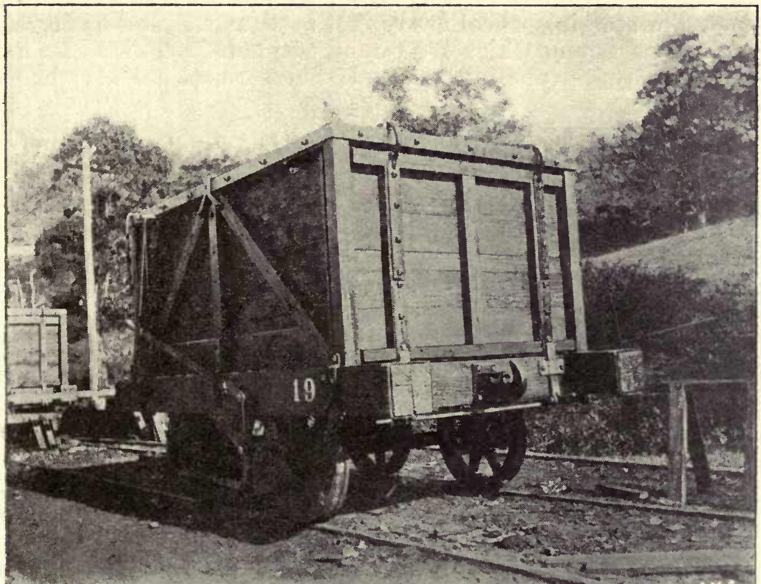


Fig. 123.—Black Truck.

cent. bismuth is poured in, at the wide end, to fill up the spaces between the wires. The antimony is added to impart hardness, and the bismuth to give fusibility. The socket is then connected to the coupling chain with a pin.

The track is very uneven, having four different grades, viz., 1:2.6, 1:4, 1:7, and 1:10; moreover, it does not run continuously in one direction, in consequence an overhead frame has had to be erected to keep the rope within bounds. An additional self-acting incline, to provide facilities for handling the output from a new tunnel is being constructed, over which the coal will be conveyed in skips to be screened at the foot.

The rope used is 3 inches in circumference. The last rope was in use for two years. The rope passes round a nine-foot diameter drum, having a brake path at either end. The speed is regulated by a man who manipulates a band brake by a downward movement, through a system of levers, ropes and chains, from a ship's steering wheel, so situated that he has a good view of the trucks travelling up and down the incline. This drum is supported on a framework well braced against the downhill pull. Water plays upon the brake to prevent the heat generated by friction from igniting the wearing blocks; the quantity of water is regulated by the brakesman with his foot. The steering wheel is five feet in diameter, and has a four-inch drum, round which are wound two half-inch diameter flexible wire ropes, one at each end. These ropes are attached to

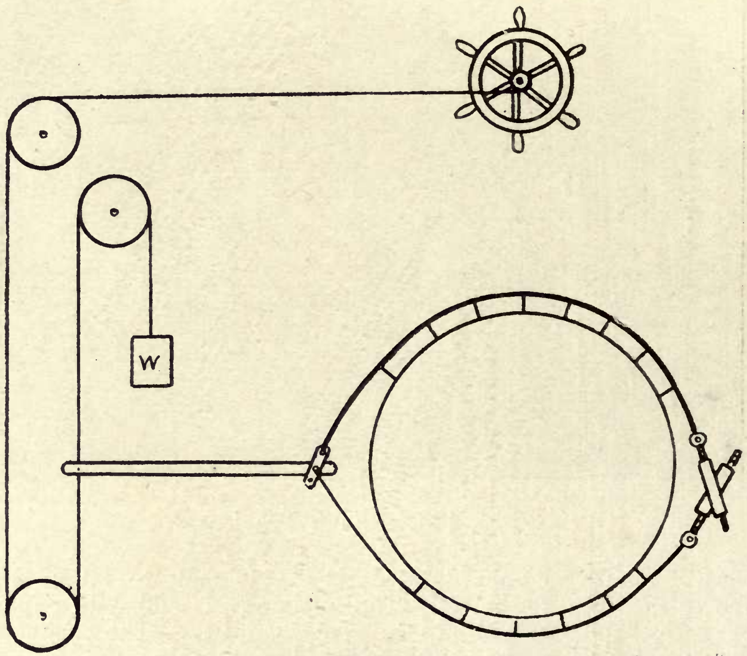


Fig. 124.—Brake for Incline.

chains which pass over and under pulleys to the brake lever, as show in Fig. 124. To the upper side of the lever is another chain with a weight attached to the end passing over a pulley, which serves to bring the lever up again, and lift the blocks off the brake path when the pressure is relieved. The lever is connected with the band brake by shafting with cranks on it, the

proportion being 16:1, and as at the steering wheel the proportion of leverage is 15:1, the total leverage on the brake is 240:1, less loss due to friction. The drum is made sufficiently long to allow the length of each of the two ropes to be coiled on in a single layer. The ropes are attached, one at each end of the drum, one is wrapped over and the other under the drum, and several spare laps of each rope are left on the drum when either rope is extended down the incline.

The colliery possesses shops fitted up with three lathes, two drills, a shaping machine, punching and shearing machine, steam hammers, etc. Many of the apparatus are made, and all the brass work is cast, on the premises. A boiler-maker is kept on the spot, but only to do repairs.

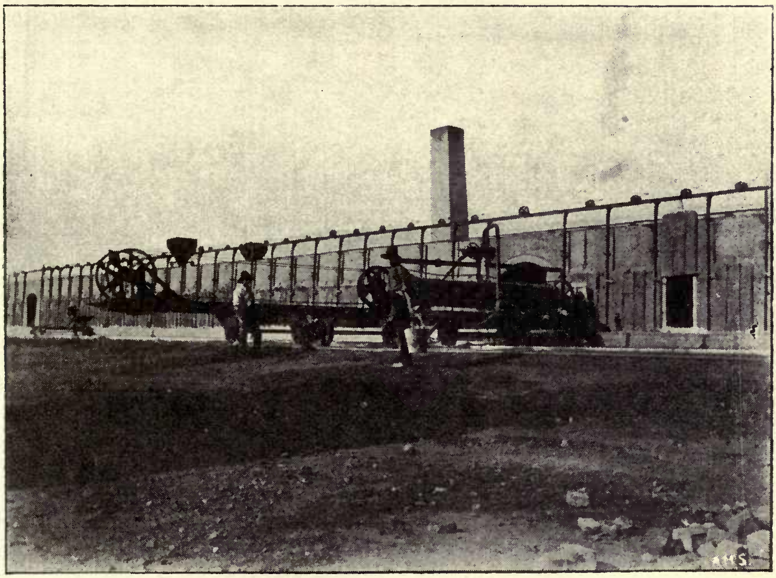


Fig. 125.—Hydraulic Ram.

The present output of South Bulli is 1550 tons per day, but they can put out 1800 tons a day when they are able to get the men. The Bellambi colliery has a daily output of 300 tons.

For storage purposes they have coal bunkers at the mine capable of holding 560 tons; bunkers for small coal at the jetty to hold 700 tons; 130 hopper trucks that hold 7 tons 10 cwt. each; 250 black trucks, having a capacity of 5 tons each, and 90 Bellambi black trucks holding 7 tons 10cwt. each, or a total storage capacity of 4160 tons.

The Broken Hill Proprietary Co.

The coke supply for this company is obtained from its own works at Bellambi. It obtains the necessary coal from the South Bulli and Bellambi collieries. There are two batteries of ovens, one containing 60 and the other 40 ovens. These ovens are 30 feet long, and somewhat higher than usual. The coke is pushed out of the ovens by hydraulic rams (Fig. 125). The oven doors are also raised by means of hydraulic rams placed at one end of a battery of ovens (Fig. 126), which work ropes backwards and forwards, to which any of the doors can be attached by chains when required. The rope for moving

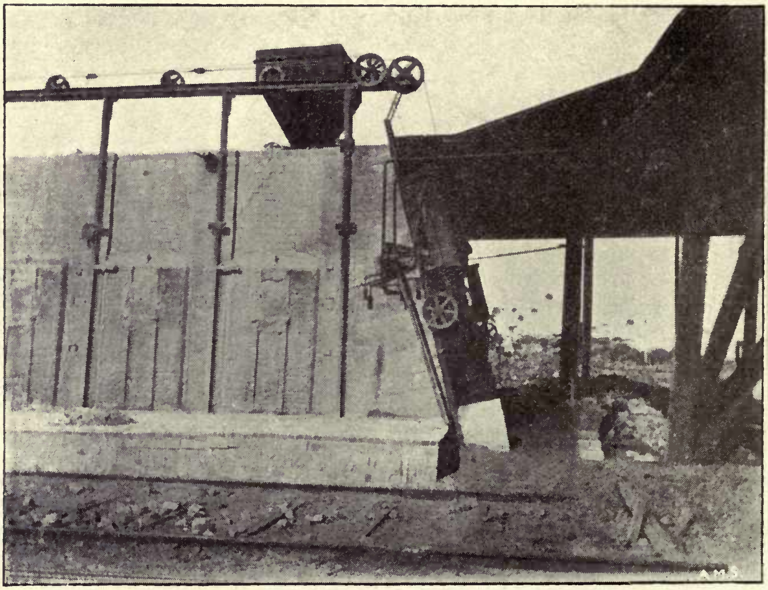


Fig. 126.—Hydraulic Ram for lifting Oven Doors.

the rams that push out the coke circulates past both batteries of ovens. These ovens differ from the ordinary rectangular ovens met with in Australia, inasmuch as they have flues both in their walls and floor, through which the hot gases pass, thus heating the ovens all round.

The Corrimal Balgownie Collieries Ltd.

The Corrimal Colliery was started in 1887-88, by Bertram, in whose time the coal was drawn from the mine to the railway by bullock teams. After working for about a year, it was leased by the Southern Coal Company, of England. This company worked it until 1891, when the present Sydney com-

pany was formed. Formerly the Corrimal and Balgownie Mines were two separate collieries, but they are now under one ownership, and the workings are connected. Mr. W. B. Pendleton has been in charge for the past five or six years.

The Balgownie Colliery has a main haulage and intake, on the right hand side of which is a return airway, while on the left hand side is another parallel heading which used to be a second return airway, but is now used as an intake, while the return air travels through old workings to the 14ft. indestructible Walker's fan, which provides 85,000 cubic feet of air per minute, with 1.7in. water gauge. Since the shaft has been connected with the workings the volume of air circulating exceeds 111,000 cubic feet per minute, and the water gauge has been reduced to 1.5 inches. This fan is driven by an engine having a 16in. diameter cylinder, with a 2½ft. stroke, provided with a Meyer's cut-off valve. Where the property widens, there are four parallel headings, two intakes, and two returns. The area of the airways is increased as the workings are extended, for by so doing the speed of the current is diminshed, and the friction against the sides correspondingly lessened.

There is only one tunnel at Corrimal, which is an intake. The gate in front of it is hung up to the roof when work is proceeding, but when the mine is idle it is let down. Being made of iron bars, it interferes very slightly with the ventilation. Now that the air shaft is completed, it acts as an intake airway, but in the course of a year or two it will probably become the only outlet for the ventilating current. The men proceed to their work in both mines through the Balgownie tunnel. All the coal (except that required for the Balgownie boilers), is drawn through the Corrimal tunnel, as all the conveniences of the self-acting incline happen to be near its mouth. Two endless rope systems are worked from the Balgownie tunnel; they run parallel for a short distance, when one continues in a westerly direction, and the other turns off northerly towards the Corrimal. The main haulage way has two curves in it, both having a deflection of about 30 degrees. The skips are conveyed by the main endless rope as far as the branch rope, which takes them on to the old main and tail rope that draws them out at Corrimal at the rate of about six miles per hour. There is a 90ft. slide between Balgownie and Corrimal, which has to be negotiated by the north and south endless rope system, so the roadway had to be driven in rock at a grade of 1 in 3½. Horses of 15.3 hands are used for gathering up the skips. At present the horses come to the surface every day, but later on, as the workings are extended, they will be stabled underground.

The endless rope haulage engine was made at the Atlas Works, Sydney, and was originally designed for a main and

tail rope system, but has been converted for its present purpose. It is on the third motion, which reduces the speed and surging of the rope. The rope, which is a Lang's lay of 3½in. circumference, is given four turns round a Fisher's pulley, i.e., a pulley with an inclined face, so that the diameter near one flange is greater than the diameter near the other flange. The rope passes on to the pulley at the side with the larger diameter, and off at the smaller diameter. As the face of the pulley gets worn down, it has other liners bolted on to it. Cast iron liners get ground down too easily, so hard steel is used, but they must not be made rough, as any roughness has to be worn down by the rope. These pulleys are thrown in and out of gear by Fisher's clutches. The tension pulley is mounted on a trolley that runs on an incline at the rear of the engine-house. The endless rope runs at the rate of 1½ miles per hour, and is dressed by drips from an oil drum suspended above the drum of the engine. Signalling can be done from any part of the hauling roadway by means of the usual electric wires. Bulb rails, weighing 26-30lb. per yard, are used in the main roadways, and bridge rails, weighing 16lb. per yard, in the bords. The present skips average 16cwt. of coal, but when the roadways are increased in length, the sides of the skips will be made higher, so as to lessen the chance of coal falling out on to the track. The skip wheels are made of Miller's chilled iron, and are imported from Edinburgh; they are found to give every satisfaction.

The bords are made 8 yards wide, and have 11 yard pillars between. The greatest inconvenience caused by rolls in the seams, which are met with in places, is having to lift the bottom to make room for the skips, and also having to pay more for coal under 5ft. in thickness. Headings from which the bords are turned off are about 18 chains apart, but the distance varies according to the output required from the mine. For the same reason, the bords are worked both to the rise and dip, instead of only to the rise. The present area being worked is so irregular, that the bords cannot be carried to their standard length on account of the cramped position. The colliery cannot be properly opened out till they get into the back country. The seam averages 7ft. thick; it is seldom under 5ft., but may be 4ft. on the top of rolls; on the other hand it is sometimes up to 10ft. thick. The seam is remarkably free from bands and sulphur. The roof is sandstone, and the floor shaley "post." In places rolls are fairly frequent in the floor, but never in the roof; they average about 2ft. 6in. in height. In rolling country, the bords are generally driven in the troughs, while the crests of the rolls are left as pillars. The pillars are extracted as soon as possible after the bords are finished, and are worked in 5 to 8 yard lifts. The coal is all

hand worked. The holing pick has a straight head, 18in. long, with diamond points, which is wedged to a 2ft. 6in. handle. Monobel is the explosive used, the shots being fired by means of electricity.

At Balgownie there are two Cornish boilers, and one multitubular locomotive type of boiler, which deliver steam at 60lb. pressure. The feed water is injected into the boilers by exhaust steam, assisted by a little live steam. The feed water becomes heated to about 200deg. F., and about one-eighth of its bulk is condensed steam. They have lately erected a small Green's economiser.

One hundred and thirty-eight chains from the main Balgownie tunnel, an air shaft, 972ft. above the sea, has been started on the top of the hill, in the water catchment area. This shaft, which is 14ft. in diameter in the clear, will have to be sunk 850ft. in order to reach the coal being worked. The shaft is lined with 9in. brickwork, all laid as stretchers, the space between the brickwork and the rock being filled with ashes. The bricks for the lining are made on the spot. The shaft is temporarily lined with boards, kept in place with iron rings, which are wedged in position, and suspended from each other by hooks. When the shaft has been sunk about 60ft. below the former section, a series of two-inch iron pins are fixed in holes drilled for them round the shaft, and a wooden curb is placed on them, which serves as a foundation for the brickwork. These curbs are left in, and are not removed when the next section of walling comes up from below. The brickwork is done from a cradle suspended from two guide ropes. The cradle weighs about two tons, and serves as a weight to keep the guide ropes taut. The bottom of each guide rope has a socket fastened to it, and this is connected to the cradle by a bridle chain fastened to two eyebolts, which pass through the woodwork of the cradle. This cradle is left in the shaft all the time, a 7ft. square hole in the centre allowing the bucket to pass through. The bucket has a runner or cross-head above it, which slides up and down on the guide ropes; this prevents the bucket from getting an undue swing on it.

Three feeders of water were struck while sinking. Below each, the brickwork was shorn back, and a garland inserted, consisting of a wooden curb, with sheet iron in front. A pipe from this leads to a lodgment cut in the rock. The first lodgment is 141ft. from the surface; the second, 256ft.; and the third 438ft. The second lodgment is 33ft. long by 9ft. wide, and 6ft. high. A brick dam is built about 5ft. high, which consists of two 9in. walls curved slightly inwards, between which clay is packed. The inner wall prevents the clay from being washed away. The clay, for its part, is impervious

to water, and further serves to fill up any cracks that may form in the outer wall.

The first water feeder, when struck, gave off 17,000 gallons per hour, and the second 8000 to 9000 gallons per hour, while the third at first gave off some 4000 gallons per hour, but soon steadied down to a constant flow of 360 gallons per hour; now the combined flow has been reduced to 1850 gallons per hour. While sinking, there were two steam pumps at the second lodgment, a single and a duplex Knowles, neither of which was powerful enough to raise the water to the surface, so the single pump was used to lift the

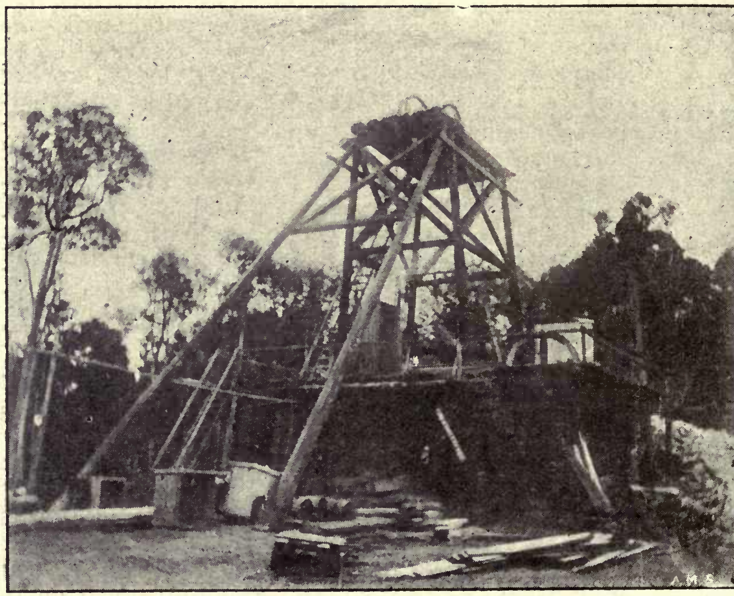


Fig. 127—Corrimal and Balgownie Air Shaft Head Frame.

water to the upper lodgment, from which the suction pipe of the duplex pump started. By diminishing the head in this manner, the duplex pump was able to raise all the water to the surface. The water from the shaft flowed into a pond, the water did not escape into the river, as it was all required for brick-making purposes. Now the water from the feeders in the shaft is carried by some 9000ft. of piping, and delivered at the surface through the daylight tunnel. Preparations are being made for the installation of two Evan's hydraulic pumps at the bottom of the air shaft, both to be operated by

the column of water in this shaft, and it is intended that they shall pump some 600 gallons per hour from a lower level, delivering it into the pipes leading to daylight. While sinking, the shaft was divided into two compartments, a downcast and upcast; the latter was formed by half-inch tongued and grooved lining boards, nailed to 9ft. long buntons placed 6ft. apart. The upcast compartment was carried up higher than the mouth of the downcast, and the air was further heated by the exhaust from the steam pump, which was led into it.

Round the mouth of the shaft is an 18in. thick brick wall, 16ft. square, built up from the solid rock. The brick cylinder lining the shaft is built up inside this square, which has a few gaps left in it when they touch, so as to tooth in the bricks of the cylinder. The corners are filled in with concrete. The head frame is made of wood (Fig. 127), the sills of which rest

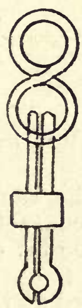


Fig. 128
Fisher's
Clip.

on the brick wall. The sinking engine, when finished with for this purpose, will be compounded (by replacing one of the cylinders with a larger one), and used for hauling purposes. Steam is raised in two Babcock and Wilcox boilers. Room for two more is provided should they be required in the future.

The clips used on the incline consist of two slightly tapered jaws, threaded on to a ring at their narrow ends, and kept together by a collar that encircles them, but which can be slid up or down according to whether it is desired to loosen or tighten the grip (Fig. 128). New clippers-on are apt to make mistakes, and allow the skips to run down the incline without properly fastening them to the rope. To prevent danger under such circumstances, the runaway switch is constructed near the top of the incline on the full track side (Fig. 129). (A) is the main track, (B) the side track, which has a grade uphill. The switch (f) is kept in position for the skips

to run into the side track by the carriage spring (g), rocker (h), and rod (e). If the clip is properly fastened to the rope, before leaving the brow of the incline, it strikes the vertical arm (d), which, through a system of levers, forces the points back so as to leave the main track clear; (i) is a piece of iron so arranged as to prevent the coupling chain from knocking against (d), which if it did would cause the skip to pass into the main track, whether it was clipped to the rope or not. The clip, if properly fastened, pushes (i) on one side, but if

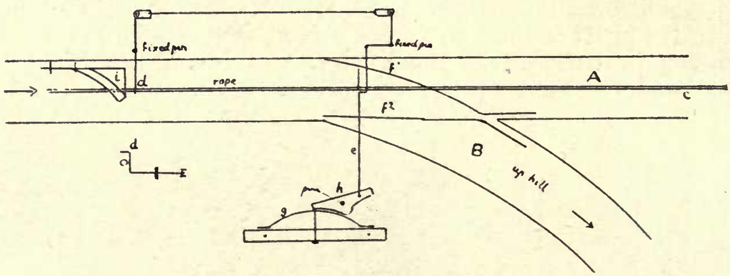


Fig. 129—Runaway Switch.

loose it slides over (i) in the same manner as the coupling chain, and not coming into contact with the arm (d) does not alter the position of the points: consequently the skip runs on to the turn-out.

A knocker off is arranged at the top of the incline on the empty side, for automatically disconnecting the skip from the rope. This consists of a forked lever mounted on an axle, and placed at an angle of 60 degrees from the vertical; it is kept in this position by a spiral spring. The rope circulates through the forked portion of the knocker, and when a clip comes along, the top of the knocker strikes the lower part of the collar on each side, and pushes it up, thus allowing the jaws of the clip to disconnect from the rope. The skip pushes the knocker forward as it passes over it, after which the latter returns to its original position, being pulled back by a spring.

The axles of the skips are lubricated by a chain greaser worked by the endless rope (Fig. 130). The endless rope passes over a sheave (a) in the centre of the track, and causes it to revolve by friction. At either end of the axle passing through this sheave, 18in. apart, is a 6in. pulley (b). Four and a half feet away on a parallel axle are two 12in. pulleys (c), in line with the smaller ones, and connected to them by chains (d). The pulleys are made out of a pair of old skip wheels, with the treads towards each other, bolted together through the flanges with $\frac{5}{8}$in. bolts and nuts. These bolts

serve as sprockets for the chains. The lubricant, which is kept in a trough, is dipped out by the chains. The chains are held up by the supports (e) and brush against the axles of the skips, thus lubricating the bearings. Any excess of oil drops into a trough on the upside of the incline, and flows back into the oil well.

The drum at the top of the incline is 5ft. 6in. in diameter, with 6in. flanges, and the rope is wound round it 3½ times. The brake path is 7ft. in diameter. About 40 h.p. is developed that has to be absorbed by the brakes. The brake-blocks are

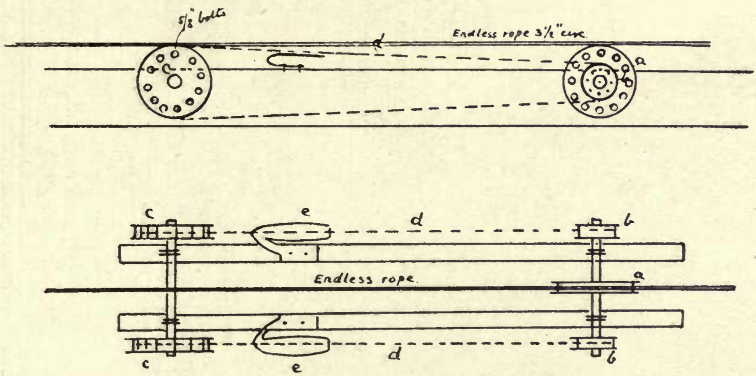


Fig. 130—Greaser for Skip Axles.

made from local "leather jacket" wood, which is not so hard as to get polished, nor so soft as to wear out too quickly. When brake blocks are being renewed, small iron clamps are bolted to the rope, and fastened to a wooden bearer across the track so as to prevent the rope from shifting. The tension pulley at the bottom of the incline is 5ft. 6in. in diameter. The skips when they come out of the mine are sent down to the screens and coal bins on a self-acting incline, for about 33 chains, after which the coal is conveyed on a private line a further distance of a mile to the Government railway.

The incline, which is sometimes made ground at others in a cutting (Fig. 131), varies in grade, and at the foot inclines in the opposite direction, but the general grade is 9 degrees. There is a double track, of 2ft. gauge between rails, laid with 26lb. per yard rails. Cast iron rollers are placed 18ft. to 20ft. apart to support the 3½in. circumference Lang's lay endless rope. The rollers are 5in. diameter and 7¾in. long, running in wooden bearings (Fig. 132). A frame two feet long is made to keep the dirt back. About every 25ft. or so, a water table is made to allow the surface water to drain off on one side, the sleepers above and below the water table being

propped apart. The sleepers are of wood, properly ballasted, placed 3ft. apart, and to these the rails, which are fished together at the joints, are dog-spiked. Every now and again a sleeper is made longer than usual, so that it can be well

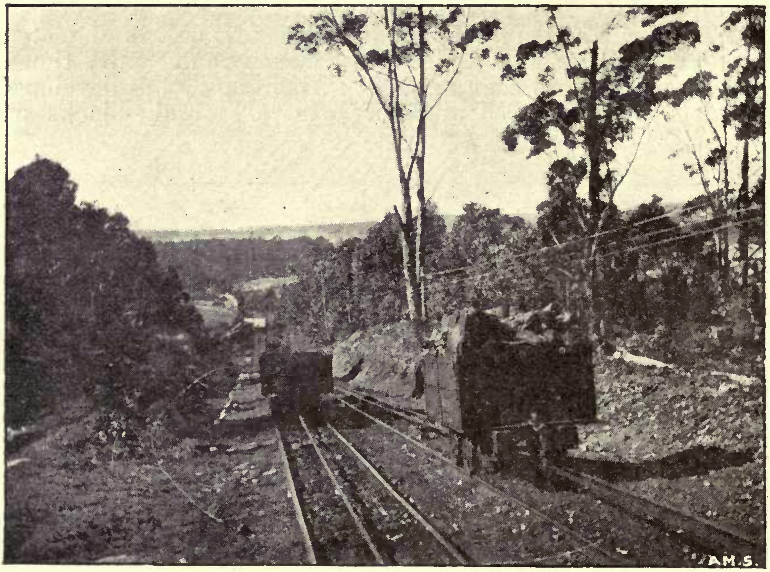


Fig. 131.—Self-acting Incline.

bedded in the ground to prevent the track from slipping down hill. The rope is of the best plough steel, made up of six strands with seven wires in each. The last rope was in use for 10 years. At the brow of the incline, as the ordinary rollers would make too sharp a bend for the rope, 18in. diameter

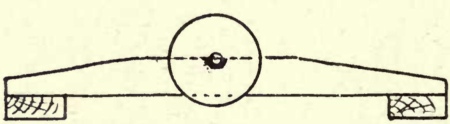


Fig. 132.—Roller and Bearings.

sheaves are used. As these sometimes unfasten the clips accidentally, a bobbin is attached to a sleeper close to the sheave, so as to catch the axle of any runaway skip. Check rails are placed parallel to the ordinary rails at the brow of the incline, so as to prevent skips running off the line.

The advantages of the endless rope system over the usual open rope system employed with the gravity planes on the South Coast, is that the weight of the rope on the up hill side is always neutralized by the weight of the rope on the down hill side; with the endless rope it does not matter if the track undulates, so long as the general fall is sufficient; with long inclines it is not necessary to have such a steep grade when employing an endless rope, as with an open rope; also the conveyance of coal is more uniform.

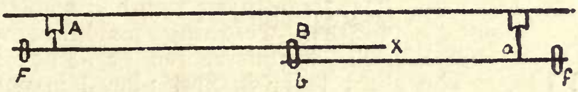


Fig. 133.

The empty skips weigh about 6cwt., and can hold 18cwt. of coal; the maximum number of skips on the incline at a time is 22 on each track, or a total weight of 26 tons 8cwt. of full trucks, and 6 tons 12cwt. of empties.

Pooley's weighing machines are now used for weighing the skips of coal.

A platform weighing machine should work equally well irrespective of the position of the load on the platform. Care

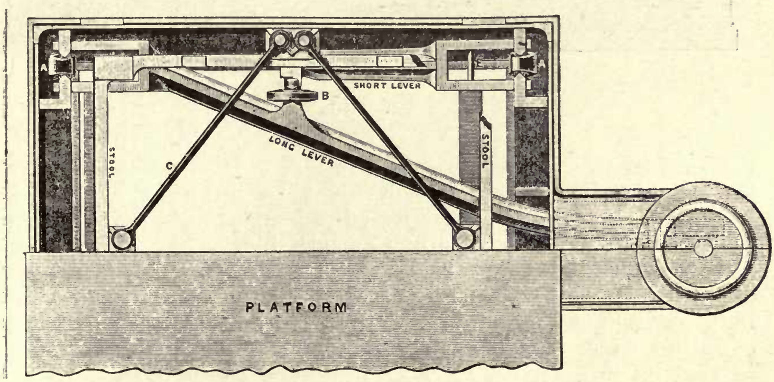
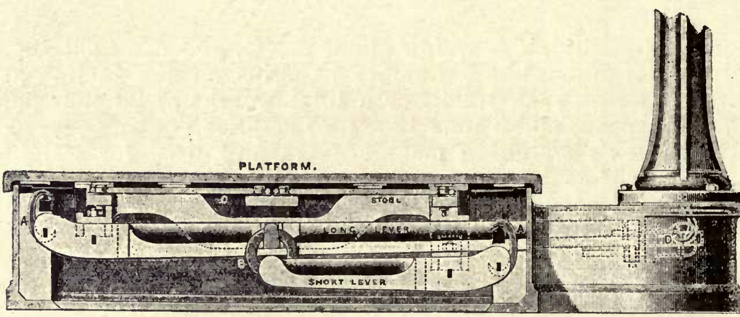


Fig. 134.—Platform Weighing Machine.—Plan View.

should be taken that the machine is level. These machines are constructed on the Beranger principle. The platform rests with one end over a lever as at (A) (Fig. 133), and the other end on a second lever as at (a). These levers must be similar, that is, the ratio of the arms (FA) to (FB) and (fa) to (fb). If this ratio be 20 to 1, then every ton on the

platform will produce a presure of 1cwt. at (B). The lever (FBX) produced to a point outside the machine is used to further reduce this pressure, which can then be measured by means of a steelyard. The proportion of the two levers being the same, whatever point on the platform the load is placed, the effect is the same; for the part that is not taken up by one lever, is taken up by the other. If the proportion of (FA) to (FB) was 1 to 4 and (fa) to (fb) 1 to 4, then the pressure at (A) will be equal to quarter of itself at B, likewise with the other lever. The instrument will therefore act as if a weight equal to a quarter of the thing weighed was suspended at (B). Pooley's platform weighing machine, which is largely used at collieries, is constructed as shown in Figs. 134 and 135. The short lever is first placed in position at



PLATFORM WEIGHING MACHINE—SECTIONAL VIEW.

Fig. 135.

the end of the box nearest the pillar. It is suspended from its fulcrum links (A), which must be hung as shown, the hooks facing inwards. Knife-edge bearings are used so as to diminish the friction as much as possible. The long lever is now passed over the back rail of the short lever into the neck of the box, its end centre (D) being the point of suspension. The long and short levers are connected together at each side by coupling rings (B), and the stool with its bearings is made to rest on the centres (E). The check links (C) are used to prevent the stool bearings from binding against the jaws of the levers. The pillar is next bolted to the neck of the box, and the steelyard hung as shown in Fig. 136. The levers and steelyard are then connected by means of a suspension rod. Finally, the platform is placed on the box so that the planed snugs rest dead upon the frame, and the machine is adjusted as follows, and should be tested every morning. The weights are removed from the plate of the counterpoise (C). The poise (P) is put back to zero on the steelyard, and the platform

swept clean, then when the machine is put in action, if correct, the point of the steelyard will vibrate gently in the guide. If it is not quite right it may be regulated by adjusting a small weight situated near the fulcrum. In the

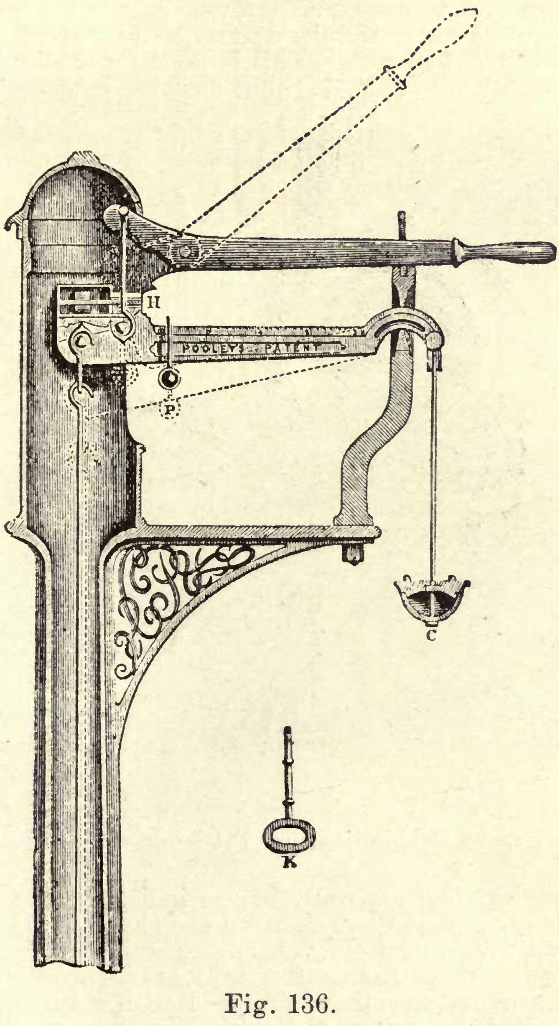


Fig. 136.

more modern machines this is concealed within the pillar to protect it from interference, and is manipulated by the key (K) through the hole (H). If, when the small weight is moved

as far as it will go towards the back end of the steelyard, the machine is not properly adjusted, turn it back as far as it will go in the opposite direction, take out the plug in counterpoise (C), and drop small shot into the cup until it is just heavy enough to bring down the point of the steelyard. So as to preserve the machine from wear, the platform should be solid upon the frame and the centres be detached from their bearings when not in use. This is done by manipulating a lever. Pooley's pit-bank weighing machine is made in many

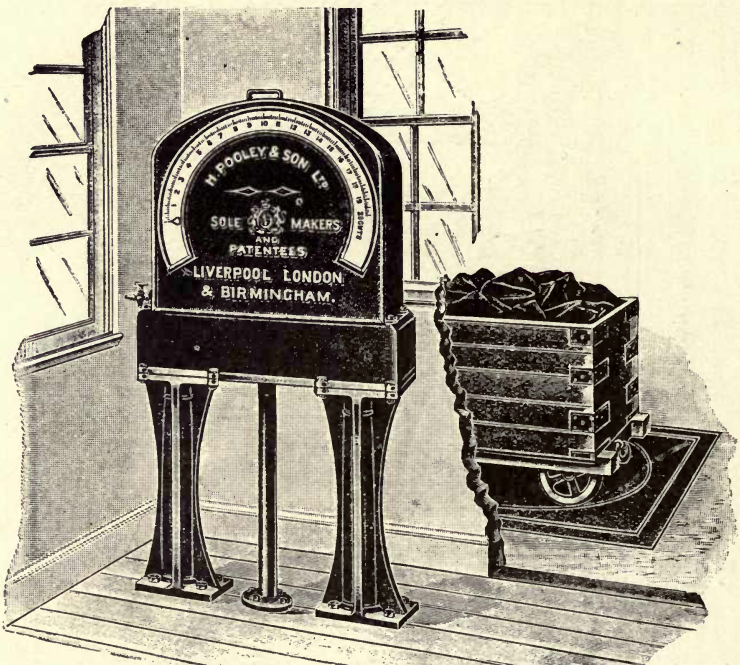


Fig. 137. Patent Self-indicating Pit-bank weighing machine

different styles, that generally in use indicating the weights automatically, so that the weighman and check weighman can readily read the figures (Fig. 137). The later machines go further, and register the nett weight on a travelling band. The platforms are sometimes provided with a turn table for facilitating the disposal of the skip. In these machines all the sustaining points are suspended, not rigid; the knife-edges are all in parallel planes, and the levers all oscillate in one direction, so there is a minimum chance of injury due to jar.

The only wear or strain to which they are subject is during the brief period of actual weighing. The great saving of time and space as also the accuracy with which the weighing is carried out, is so patent to those who have occasion to handle large weights, that this type of machine has practically superseded the old beam scale formerly employed for this class of work. The tare of a number of empties having been found, and the average struck, the steelyard is so weighted that when an empty skip is on the platform, the index reads zero; consequently, when a full skip is weighed, only the actual weight of coal is indicated, which can be at once noted down without any calculation.

Fig. 138.—Australian Coal Works.

The electric plant consists of a Westinghouse shunt-wound direct current generator of 7kw. 31 amp. 225 E.M.F., full load speed 1350. It drives two electric pumps, and also furnishes some light. One pump is a reciprocating geared pump. The other is a Quimby screw pump.

The Australian Coke Company.

These works are located at Unanderra, and are under the charge of Mr. Walter Evans. The coal for coking purposes is obtained from the Corrimal Balgownie Collieries. There

are 82 beehive ovens altogether, varying in capacity from $4\frac{1}{2}$ to $6\frac{1}{2}$ tons, which are drawn twice a week (Fig. 138). The form of the beehive oven was probably originally copied from the dome-shaped mounds made by charcoal burners, and its appearance gave it the name of beehive. Beehive coke has the name of being the best for metallurgical purposes; it has its full cellular structure developed, assuring a maximum calorific value. It has a bright, silvery coating, seen more especially in the upper parts of a charge, due to carbon deposited on the coke brought up by the hydrocarbon gases from the coal lower down, through the incandescent section of the coked coal. By quenching the coke in the oven, the amount of moisture left in the coke is reduced to the least possible quantity. The cost of labour, and waste of carbon, is greater when coking in beehive ovens than in some other varieties.

Mt. Pleasant Coal and Iron Company.

This colliery is under the management of Mr. T. Cook, who has been in charge for the past 16 years; but the place has been worked for some 40 years. The word iron used in connection with this company is on account of some unworked clayband on the property. An attempt was made to treat some of this iron a few years ago in a small blast furnace, the ruin of which is to be seen at the foot of an incline. There is but a very slight chance of this iron ever being worked at a profit.

Being hedged in all round by other mines, this colliery cannot expand towards the west, like its neighbours. The present output of coal is 750 tons per diem, but when the main and tail rope system of haulage now in use gives place to the endless rope system, the output can be increased to 1000 tons. The coal is holed by pick.

The skips are drawn underground by means of a main and tail rope which passes down the main haulage and intake tunnel; the different districts have their own branch tail ropes. On arrival at daylight, the skips are weighed on a Pooley's weighing machine, and are then attached to another main and tail rope system worked by a Mort's Dock engine, which runs along a somewhat crooked track for $1\frac{1}{4}$ miles to the head of the incline. The worst part of this track is being straightened, which should make a great difference in the friction to be overcome, and also in the wear of the ropes and pulleys. Thirty skips form a set on this line, and the rope travels at the rate of about six miles an hour. An ordinary greaser is placed on the track, but judging from the way the grease is splashed about, the skips evidently travel too fast for such an arrangement. On reaching the end of the surface main and tail rope line, the skips are emptied on to screens from end-tipplers,

which grip the skips by the wheels. The coal is then loaded into hopper trucks, wooden or iron, and drawn by horses to the top of a self-acting incline, which is about three-quarters of a mile long. The line has three rails above and below the passing, where of course there are four. The speed is regulated by brakes having cast iron shoes instead of the customary wooden blocks, and these brakes are manipulated by the usual ships' steering wheel by the man in charge. At the bottom of the steep incline there is another incline, nearly flat, for half a mile, having three rails at the top end, four in the centre, and two at the lower end. At the bottom of this incline is a Pooley's weighing machine, and after that the trucks are taken in charge by a small locomotive. The line is continued for another one and a half miles to the Wollongong basin, where most of the coal is shipped, but occasionally some is shipped to Port Kembla or Darling Harbour.

On the south coast, where there are so many self-acting inclines, the following notes, mostly abstracted from Alexander Bowie's paper on "Problems in Hauling and Hoisting"* may be of interest:—

Let (a) be the angle of inclination.
(C) the coefficient of friction of trucks and ropes.
(W) the weight in lbs. of the loaded truck.
(w) the weight in lbs. of the empty truck.
(r) the weight of the rope for the length of the incline in lbs.
(C^1) the coefficient of friction for the drum.
(f) the amount of resistance due to friction for drum in lbs., or $= 2\,C^1\,[(w + r) \sin a + C\,(w + r) \cos a]$.

The coefficient of friction is equal to the tangent of the angle of inclination on which the force exerted by gravity is exactly counterbalanced by the frictional resistance. This angle is known as "the angle of friction," the "angle of repose," or "the limiting angle of frictional stability."

When a waggon (W) is placed on an inclined plane, the force with which it tends to move down the plane, disregarding friction, is—

$$W \sin a.$$

As the amount of friction equals the pressure multiplied by the coefficient of friction, the amount of friction encountered in moving a waggon (W) on an inclined plane is—

$$WC \cos a.$$

When $W \sin a = WC \cos a$, or $\dfrac{\sin a}{\cos a} = \tan a = C$

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*T. Am. I. M. E., 1901. Vol.XXXI., p. 265.

the force with which the waggon tends to move down hill is exactly held in equilibrium by the amount of friction. The force with which a loaded waggon tends to move down the plane when the angle of inclination exceeds the angle of friction is—

$$W \sin a - WC \cos a$$

and under the same conditions, the force with which the empty waggon resists motion up the hill is—

$$W \sin a + WC \cos a.$$

The smaller the difference between (W) and (w) the greater the angle of slope required to make a self-acting plane.

One must also consider the weight of the rope and its friction on the rollers of the incline, and the friction on the periphery and axle of the drum round which the rope passes.

The principal factors in determining the coefficient of friction for wheeled carriages moving on rails are the ratio of the diameter of the wheel to that of the axle, the quality of the lubricant, and the smoothness of the contact surfaces. Take the coefficient of friction for the rope on the rollers as being the same as that of the waggon, though it should really be a little greater on account of the sag of the rope and the roughness of its surface, the resistance offered by the rope will be continually decreasing as the empty car ascends the plane. The required angle of inclination will increase with the length of the incline.

So long as $W \sin a > (w + r) \sin a + C (W + w + r) \cos a$, the conditions permit a self-acting plane, but when W sin a is equal to or smaller than the second member of this formula, no motion can be produced by gravity alone.

As the weights for steel ropes are nearly in proportion to their respective safe working strengths, if the load is increased, the weight of the rope in the same ratio must also be increased. Therefore, the angle sought would be the same for any number of waggons per trip as for one waggon. But if the rope used for a one-waggon trip is stronger than necessary, so that additional waggons can be put on without using a heavier rope, then it may be possible to make the plane self-acting by simply increasing the number of waggons in a set.

As the resistance of the empty waggon and rope to the motion up the plane is—

$$(w + r) \sin a + C (w + r) \cos a$$

the strain executed by the loaded car to move down must be at least equal to this; hence the strain on the drum round which the connecting rope passes must be at least

$$2[(w + r) \sin a + C (w + r) \cos a].$$

The tangent of angle of minimum grade of a self-acting gravity-incline when all resistances of gravity and friction are considered, equals—

$$\frac{C\ (W + w + r) \times \dfrac{f}{\cos a}}{W - (w + r)}$$

If there is not much to spare above the necessary grade, there should be a short piece of level track at the bottom of the incline, and if necessary a heavier grade at the top, so that the waggons can start easier. It is best practice to have the grade as nearly uniform as possible. Anyhow, there should not be too sudden a change in level, or else the waggon, when passing from a steep grade to a lighter one may have the upper wheels lifted off the track by the rope. The frictional resistance encountered in starting from a state of rest may

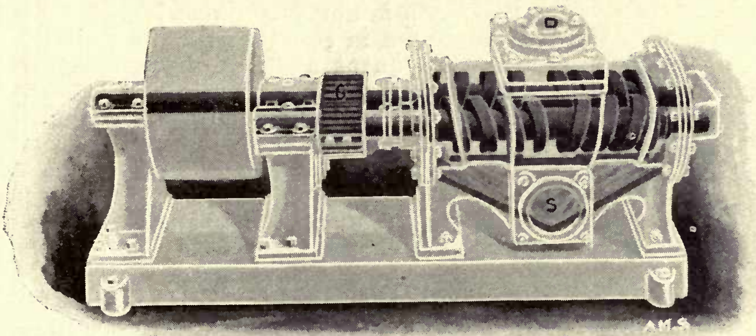

Fig 139.—The Quimby Screw Pump.

be taken as at about twice the friction of motion. If the grade is made greater at the top and lighter at the bottom, the speed due to acceleration will diminish, as the motive force varies with the size of the angle of inclination; the inertia carries the waggons over the flat portion.

Ventilation is carried out with the assistance of a 14-foot Walker's fan.

One of the pumps in this mine is a Quimby screw, driven by electricity. The dynamo for this purpose is also used for generating the light required about the place. The pump, as shown in Fig. 139, consists of four screws mounted in pairs on parallel shafts, and so arranged that in each pair the thread of one screw projects to the bottom of the space between the threads of the opposite screws. The screw threads

have flat faces and peculiarly undercut sides, the width of the face and the base of the thread being one half the pitch. The pump cylinder fits the perimeters of the thread, space enough being left between the screws and the cylinder and between the faces of the intermeshing threads to allow a close-running fit without actual contact. There is no end thrust of the screws in their bearings, because the back pressure of the column of liquid is delivered to the middle of the cylinder, and the endwise pressure upon the screws in one direction is exactly counterbalanced by a like pressure in the opposite direction. The suction connection opens into a chamber underneath the pump cylinders. The water passes through the chamber to the two ends of the cylinder, and is forced from there to the centre by the two pairs of intermeshing threads, the discharge being in the middle of the top of the cylinder (D). The power to drive the pump is applied to one of the shafts, the second shaft being driven by means of a pair of gears (G). Having no valves, no internal packing, and no small moving parts, the pump is not very liable to get out of order, and as the screws are not in contact with the cylinders or with each other, the consequent absence of wearing surfaces gives the pump great durability. The rotary motion of all the moving parts and the continuous flow of water does away with the churning effect produced by reciprocating pumps.

The locomotive shed and workshops are erected on the flat opposite the company's coke works, which are at present leased to Messrs. Figtree. There are 42 beehive ovens in this plant.

The Osborne-Wallsend Colliery.

This colliery, commonly known as Mount Keira Colliery, is situated near Wollongong; it has been managed by Mr. J. C. Jones for the past six years on behalf of Messrs. E. Vickery and Sons, Ltd., the under-manager being Mr. Bissell. This is the oldest colliery on the South Coast, having started operations fifty or sixty years ago.

There are three tunnels penetrating the mountain, all of which are intakes. One is the main haulage tunnel, another is the travelling road, while the third is only used for ventilation purposes. The stentons connecting two tunnels, when no longer required, are generally stopped with four and a half inch brickwork, which is found sufficient if the roof is not too heavy; but the wall is made thicker at the sides where the coal is not so strong. An air shaft three hundred feet deep sunk from the top of the mountain, is situated about two miles N.W. from the entrance of the main tunnel; this serves as an upcast, the air being sucked out by a 12ft. Walker fan. This fan is driven by three ropes from an engine. There is a pair of

single cylinder horizontal engines arranged end on, but only one is used at a time, the other being held in reserve in case of necessity. The air is split in the air drift so that it can be drawn through the fan from both sides. The top of the air drift is made of galvanised iron, which is purposely made the weakest part, so that in case of an explosion, this will give way and can be readily repaired, instead of the fan becoming destroyed. When men are at work, the fan makes forty revolutions per minute, using a pressure of one and one-tenth inch water gauge; but when the mine is idle, it is only given twenty revolutions.

There are two water rings in the shaft made by building in ordinary wooden curbs, above which the brickwork is shorn back; on to the front of the curb is fastened a rim of sheet iron to retain the water which is eventually led down the side of the shaft in a pipe. There is a single cage in the air shaft that runs on rope guides, the hoisting being done by a geared duplex engine, which drives the single drum. Electric signals and telephones are used throughout the mine.

The seam being worked averages 7ft. 6in. in thickness, but in places it is subject to rolls where the floor rises up; the roof is seldom affected. The tops of the rolls are invariably accompanied by so-called grey heads, which are joints, running in the same direction as the longer axis of the roll, coated with a whitish substance. By the trend of these grey heads, the miners can tell how the rolls are running. They are also known as "leaners," as their faces incline towards the axis of a roll.

The coal is worked by the ordinary bord and pillar method. The bords are started with a four yard neck, and are then widened out on either side to eight yards. If the coal will not stand well, the pillars are worked out quickly. When winning pillars, the coal is extracted in eight yard lifts. A series of pillars are worked out at an angle so as to leave strong ground behind the men for escape in case of necessity. The holing is all done by pick, and the coal is shovel-filled. When the coal has to be blasted down, monobel is used as the explosive. Old double-headed rails resting in chairs set in the rock serve as collars in the return air-ways, where wood might rot with damp and fungi.

Formerly the main and tail rope system of haulage was employed underground, but this has now given place to the endless rope system. The effect of the great strain on the old drums, due partly to the rope which is wound on hot during the day and remains coiled up during the night, when it cools and contracts, can be seen by the way it has had to be

reinforced. The present system brings out four skips in a set, at the rate of one and a half miles per hour, which experience proves to be fast enough to prevent accidents; but on the surface the endless rope system works quicker, from two to four miles per hour. There are two main districts, the north and south, each supplied with a separate haulage: the northern rope also actuates one of the branches of the southern district by means of gearing. There are four jigs, or underground, self-acting inclines, which supply the main southern rope where the seam becomes steep. There are four places along a

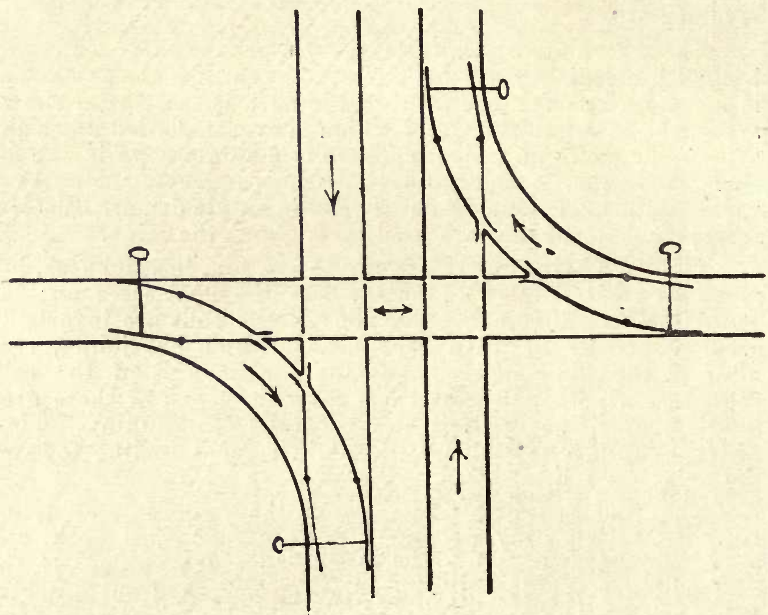

Fig. 140.

jig where skips may branch off to workings; the arrangement of such flats is shown at Fig. 140. The drums at the top of the jigs are provided with brake bands, top and bottom, which have blocks of leather-jacket wood bolted to them. The endless rope is driven by a Tangye duplex horizontal engine, having 20in. diameter cylinders, and a 3ft. stroke. This engine works the two main endless ropes. The rope pulley has a steel liner which is bolted inside the groove, and can be renewed when worn. The face of the pulley is slightly inclined from one side to the other, so that the rope which passes on to the pulley at that side with the lesser diameter, after coiling round

the pulley five times, takes off on the higher side. The tension varies in all parts of the rope, being greatest where it passes on to the driving pulley, and least where it passes off it. Fisher's friction clutches are used to throw the rope systems into gear (Figs. 141 and 142). The rope pulley (f) and brake path (k) run loose on the main shafting (h), but a driving drum (g) is keyed to the shafting, and revolves with it. The clutch consists of three segments (a) which surround the driving drum, and are bolted through oblong slots in the arms of the pulley. The segments of the clutch are united to-

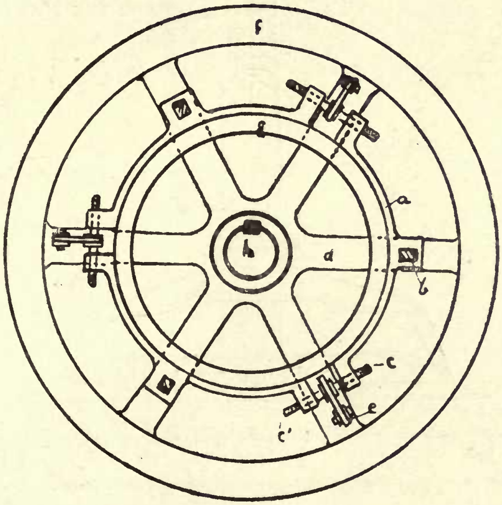

Fig. 141.—Fisher's Friction Clutch (elevation).

gether by right and left hand screws (c, c), the clutch is put in or out of gear by the ordinary fork (i) and lever (j) arrangement, which brings a system of levers into play, and either forces the segments to press on the driving drum, when the levers are pushed towards it, or causes them to be withdrawn when the motion is reversed. The segments are shod with brass so as to get more adhesion, and save the wearing of the driving drum and segments. As the segments are attached to the rope pulley, when they grip the revolving driving drum, they cause the rope pulley to become a part of the moving body. When the clutch is thrown into gear, the friction slips at first, thereby avoiding a strain on the machinery, and the pulley moves slowly until the inertia of its load is overcome. The endless rope system is suitable for undulating ground, as

the up and down grades help to balance one another; the uniform conveyance of single skips or small sets is better adapted to colliery work than long trains, which require an accumulation of skips at flats and at the surface; also as the engine is running the whole time, power is more evenly used, and less powerful engines are required than with the main and tail rope system for equal distances. For the underground haulage, screw clips are used. If they used Fisher's clips, the thimble would become pushed up while passing round the sheaves at horizontal curves; besides they are found to be not strong enough to hold four loaded skips at a time travelling up hill. When a rail crosses the track of a rope, the rail is cut through as far as the flange, so as to leave a space for the rope to pass

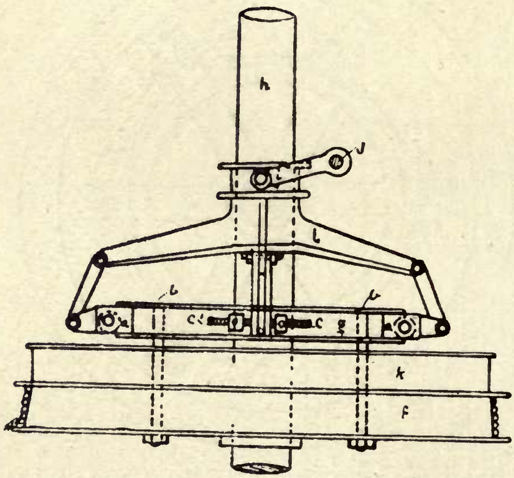

Fig. 142.—Fisher's Friction Clutch.

through. At a kip, the rails are fastened to longitudinal sleepers, so as to allow the rope to keep down out of the way. At a horizontal curve a series of vertical sheaves, called "tommy dodds," are arranged near the centre of the track, so as to guide the rope. In one place where the track had a curve when on an incline, they originally had a good deal of trouble, as the rope used to rise. Now the grade is eased before rounding the corner, so the rope tends to travel faster than the skip, and this causes the clip to be pulled under the skip, and drag it along, which has the effect of keeping the rope down instead of allowing it to rise. In one place, where a single track is laid along a heading over which both full and empties run to serve a horse track that branch off from it, an arrangement is laid out, as shown in Fig. 143, where the empties are

switched on to the branch horse track as required from one end of a flat, while the full returns pass an automatic switch on to the main track at the other end of the flat.

At the surface the coal is lowered down the mountain side to the screens a mile away, along two series of self-acting inclines, worked with circulating endless ropes. From the screens, the coal is conveyed by locomotive along a private

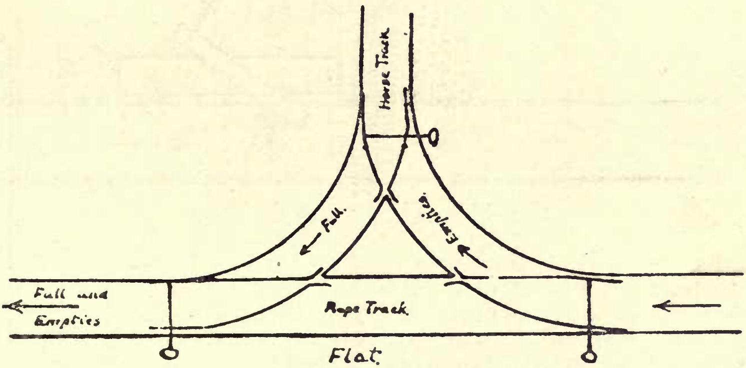

Fig. 143.

railway line for 1½ miles, to the South Coast line, and a mile further on to the Woollongong basin, from which most of the coal is shipped. The locomotive can only take up 12 empty waggons at a time, as the up grade is too steep for it to draw more. On the self-acting incline, certain safety provisions have been made in case of a break-away. On the up line, bobbins are placed between the rails to catch the axle of a skip should it go down hill instead of up. This bobbin consists of a bar of

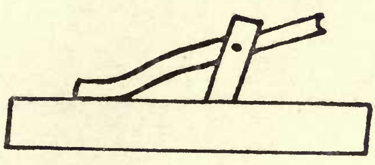

Fig. 144—Bobbin.

iron through which a pin passses in such a manner that one end is heavier than the other (Fig. 144). The consequence is that the shorter end is raised up. The higher end, which has a recess cut out to engage with the axle of the skip, is placed pointing up hill. As the bar is free to move, the up-coming skip simply depresses it when passing over, but the bar immediately rights itself, and is ready for action as soon as the

skip has passed. A block of wood is also used to throw skips clear of the line in case of a break-away, as shown in Fig. 145. The up-coming skip pushes the block on one side, but as soon as the wheels have passed, a weight draws it back again across the rail. On the down line a throw-off switch is worked by means of a set of levers by the man at the brow of the incline.

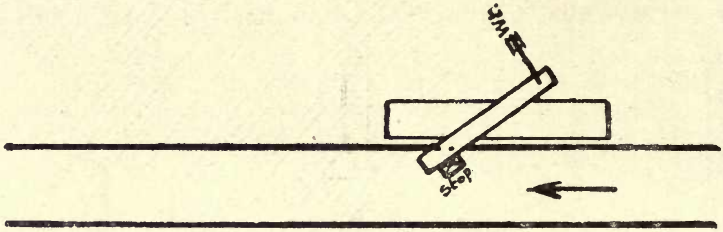

Fig 145—Throw off Switch.

If he sees a skip running away, he turns a lever (Fig. 146), which causes a block of wood to be placed across the outer rail; when the skip comes up to this, it is thrown off the line. Sometimes the manipulation of one lever is made to work two throw-off switches, some distance apart; the second one being used in case the skip passed the first before it could be put into action.

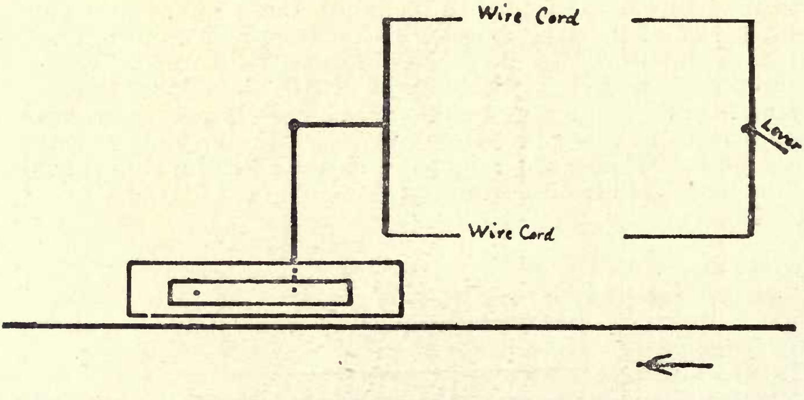

Fig. 146—Thow off Switch.

The upper switch is not far from the brow of the incline, as a skip is more likely to escape down hill before it is fastened to the rope than it is to break away from the rope.

No pumps are used at this colliery, in fact the mine being dusty the haulage-ways have to be watered. This is done by means of a water-tub, which is a closed-in water-tight tank

mounted on an under-carriage like an ordinary skip. A rod has one end attached eccentrically to one of the wheels, while the other is connected to a rocking arm which gives motion to another rod that works up and down and communicates motion to the handle of a semi-rotary pump. Water is forced by this pump into perforated pipes, from which it is sprayed on to the ground (Fig. 147).

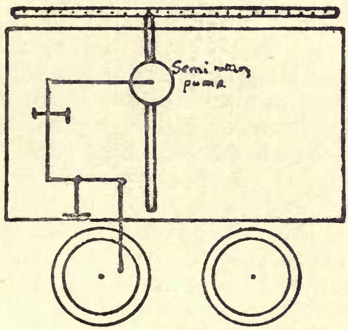

Fig. 147—Water Tub.

There is a saw-mill near the top of the hill, and a fitting shop at the foot of the incline near the screens and Pooley's weighing-machine.

Federal Coke Company.

These coke works are managed by Mr. J. A. Figtree, and consist of 40 ovens. These ovens, which are of the McLanahan type—an improvement on the old Welsh oven—were the first of their sort to be erected in Australia, except two built for experimental purposes by the Australian Coke Company, since converted into ordinary beehive ovens, as they had no ram to push out the coke, and the draught passing through the ovens seriously inconvenienced the man drawing the coke at one end.

These rectangular ovens, except for their form, are to all intents and purposes worked as a beehive, till it comes to the matter of drawing the coke, when a ram is employed to push it out. In the case of the Federal Coke Company's plant, this is a steam ram. This ram saves much time and labour. The ovens are 30ft. long, 7½ft. wide at the ram end, and 8ft. wide at the other end, while the height is 6ft. Being larger than the ordinary beehive, they have a larger capacity, viz., 9½ tons, but are also charged twice a week. They could be charged three times a week, but it is found that by burning slowly, with a larger charge, the coke is denser than when burning quicker with a shallower charge. There are two

charging ports in the crown of each oven. The grade of the rails laid along the top of a bank of ovens should be one per cent., so as to assist in handling the charging canisters. The firebricks are laid in loam or loam and clay, for if lime mortar was heated and then played on with water, it would slack. The doors of the ovens are raised and lowered by overhead hand winches.

The coal is obtained from the Mount Kiera colliery, and after being tipped out is conveyed to the disintegrator shed by a bucket elevator. The Carr's disintegrator is 3ft. 6in. in diameter, and is capable of treating 200 tons in eight hours.

No exact tests appear to have been made at the various Australian coke works relative to the difference in bulk and weight between the coal charged and the coke produced. If a battery of ovens yields 65 per cent. of coke, and by more careful work, either in the construction of the ovens or in the supervision of the process, this is increased one per cent., then there has been an absolute saving of 1-65th, or 1.53 per cent. of the total value of the coke formerly produced, less the cost of loading, for all the other expenses remain the same. There are no by-product ovens in Australia. It is doubtful, however, whether, under local conditions, the amount of volatile hydrocarbons would produce sufficient by-products to pay interest on the necessary plant. Good coke, besides the fixed carbon and ash, will contain a little volatile matter and water, consequently the actual results of coke burning are not quite the same as that shown by laboratory tests.

The amount of ash in a coke may be increased above that contained in the original coal, by the ash from the coke burnt in the oven to give the necessary heat, by handling coke in a dirty place, and from impure water used for quenching. Some people claim that an increase of ash in a coke, up to a certain limit, is an advantage, inasmuch as it increases the hardness of the coke. But this only appears to be true when the ash is a part of the structure, and not when it is derived from outside sources; the latter being further objected to since it is paid for as coke, and so far from giving off heat, requires not only heat, but fluxes to get rid of it, and takes more handling. Commercial coke is the theoretical yield less the loss in burning, and that of fine coke, or "breeze," in handling; it is, however, increased by the ashes and dirt gathered up. The loss in burning commercial coke should not be more than 3 to 5 per cent. below the theoretical amount.*

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*Catlett (C,) "Coking in Bee-Hive Ovens with Reference to Yield" (T. Am. Inst. Min. Eng., xxxiii., p 272, 1903).

If a beehive oven is not properly attended to, a large amount of coke may be consumed that might otherwise be saved with reasonable care and attention. The burnt coke deposits ash on the remainder, which retards the transmission of heat from the hottest portion of the oven, just above the coke, to the unburnt portion, towards the bottom, and, when watered, the ash is washed down, thus increasing the total of the ash in the coke below. Pretty feathery and stalactitic forms are often seen, especially at the top of a charge; these are due to carbon that has been deposited in the coke from the decomposition of the gases distilled from the coal lower down. To obtain a good yield of coke, the charging and drawing should be done regularly, the coal properly levelled down, and the coke watered to the best advantage. Skill and care are required in controlling the admission or exclusion of air to the oven, so as to secure a satisfactory degree of heat at the right time, and as nearly as possible to secure this heat from the gases which are driven off during the process of coking, and which would otherwise be entirely wasted. Full control must be had over the air holes and small leaks which might admit air when not wanted. It is not necessary to have a large amount of air to burn out an oven; every cubic foot of unnecessary air going into an oven causes a loss. An increase of air does not necessarily mean increased temperature. At first an excess of air may cool an oven before the gases, which add to the heat by their combustion, are given off. For the first few hours more gases may be given off than the ordinary air holes can supply with air for perfect combustion, and the products of combustion may have a difficulty in escaping. Later on matters are reversed, and there would be an excess of air if it were not regulated, and as this tends to cool the charge, one may have to burn some coke to obtain sufficient heat to finish the operation. After drawing a charge, the doors are lowered again and luted, in order to keep the oven warm, so when a fresh charge is dropped in and levelled, the heat stored in the walls is sufficient to start combustion.

The Mount Kembla Colliery.

This is the most southern productive colliery in New South Wales. Coal extends further south, but up to the present it has not been proved suitable for mining. This colliery is best known to the public as having been the scene of the greatest colliery disaster in Australia, which took place about 2 p.m. on the 31st July, 1902, whereby 95 men lost their lives, and 14 were injured. A monument, erected to the memory of those who were killed, is to be seen in a street of Wollongong, and will remind those in future generations of the dangers attend-

ing local coal-mining. The force of the blast from the main tunnel wrecked the engine-house, which was situated right in line with, and a few yards from, the mouth of the tunnel. Fig. 148 shows the state of the surface after the explosion.

A Royal Commission was appointed to inquire into the cause of the disaster. The centre of interest was the No. 1 Right Main Level (the Eastern District of the mine). On the right-hand—eastern—side of this road, between the third and fifth Right Rope Roads, there was an area of 35 acres from which the coal had been extracted, and where the roof had been allowed to fall, forming a goaf; this was known as "the 35-acre waste," or "the 4th Right Goaf." The last portion of this area to be worked was that near the end of the 4th Right Rope Road, where, about a fortnight before the disaster, the last pillars of coal were extracted, and the props supporting the roof were withdrawn, with the object of letting it fall. A week before the accident, there was a fall of 2½ft., but there still remained a space of more than 5ft. between the fallen mass and the roof above. So far as the workings had penetrated in No. 1 Right District, the seam was found to be rising towards the north, from a point near the 4th Right. The coal in this mine was known to give off firedamp. Mr. Ronaldson, a former manager of Mt. Kembla colliery, admitted in evidence, given in 1895, before the Royal Commission on the Coal Mines Regulation Bill, that gas was given off rarely. Mr. W. Rogers, the present manager, stated in his evidence at the inquiry that he knew the seam gave off gas. The Chief Inspector of Coal Mines had also detected up to 1½ per cent. with the hydrogen lamp, and several miners gave evidence that gas had fired after a shot, and at their flare lamps. There is a certain amount of doubt as to whether the gas noticed by the miners after a powder shot may not have been largely carbon monoxide; but from other evidence, and the fact that the members of the Commission themselves found firedamp in several widely distant parts of the mine, there is little doubt that from the opening of the mine to the present day, it has been capable of producing enough firedamp to warrant the assumption that, given favourable conditions for accumulation, a dangerous collection might be found in almost any part of the workings.

Dr. Robertson, the consulting engineer to the Mount Kembla Coal Company, did not think the evidences of force he saw in the mine could be accounted for by the theory of a gas explosion; it seemed to him that all the appearances could be reconciled by the theory that a great wind-blast was forced out by a fall in the 35-acre goaf at the end of the 4th Right, and that the damage was done by percussion throughout the mine without any explosion; in fact, according to him, there

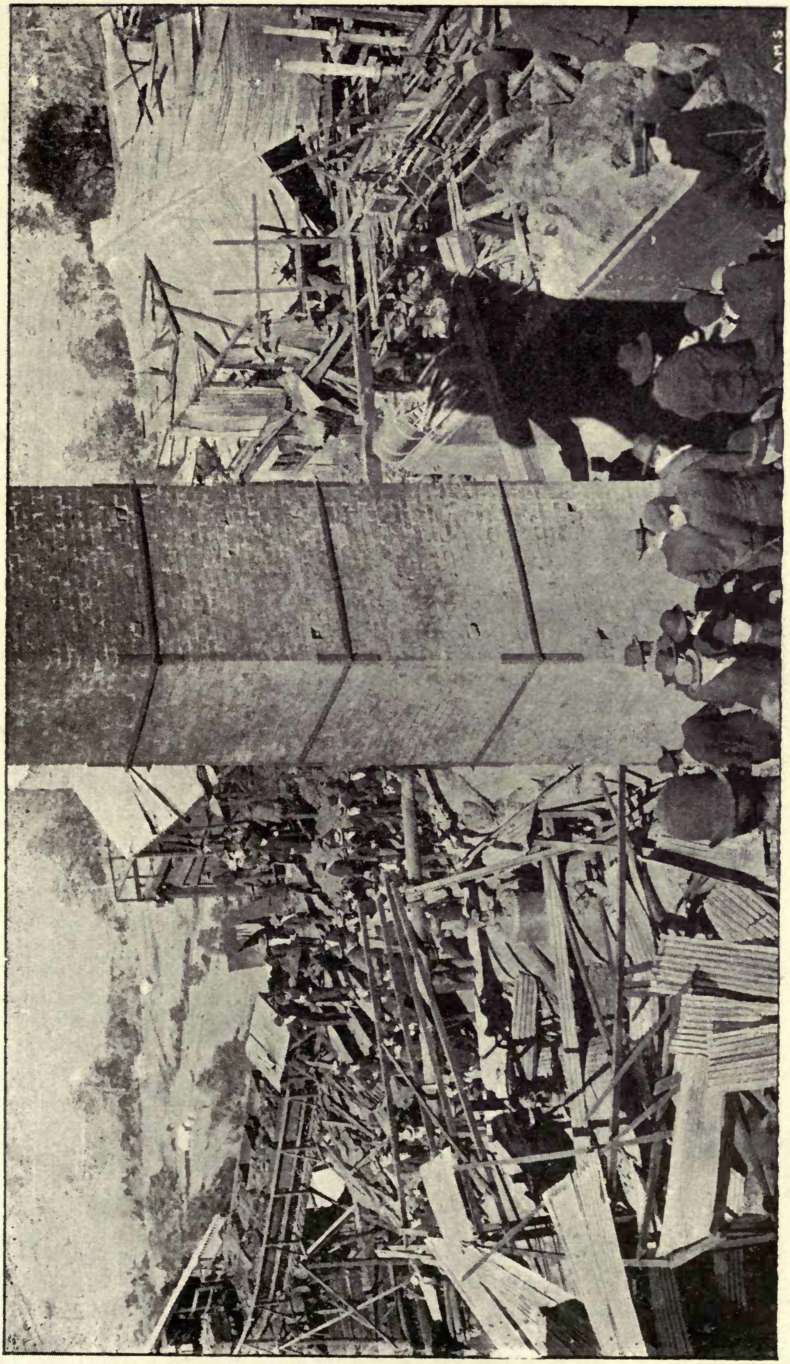

Fig. 148.—Wreck at Mount Kembla after the 1902 explosion.

was practically no evidence of flame or heat. He, however, admitted in cross-examination that carbon monoxide played a part in the after effects of his supposed wind-blast, and that carbon monoxide, under the circumstances, could only be produced by the incomplete combustion of coal dust; but he thought the heat produced by the compression of the air was sufficient to cause the coal dust to distil without flame. Assuming that an area of roof 44 yards square fell in a block in a little under half a second from a height of six feet, and that 50 per cent. of the air beneath the falling roof escaped into the surrounding goaf, or into the space from which the fall came, he reckoned that the velocity of air out of the 4th Right would be 700 miles per hour. The damage done at a great distance from the 4th Right, such as the overturning of skips at Price's Flat, 32 chains away by road, which could not have been caused by the direct force of the wind-blast, he accounted for by saying that the percussion produced by the fall would operate at long distances, though there would be no direct forcible motion of the air. He did not see any smoke himself; but the smoke of which the witnesses had spoken would be caused by the distillation of the dust. He could not account for the heat observed by several witnesses in the mine shortly after the disaster, except by the disarrangement of the ventilation.

These remarkable views appear to have had little or no support by facts. As emanating from the consulting engineer, they were given due consideration, but the Commission considered this wind-blast theory depended on too many assumptions, some of which were quite untenable. It was assumed that an area of roof 44 yards square fell in a body from a height of 4ft. 6in. above the floor; that the time of falling was about half a second (the rate at which it would fall in vacuo); and that it would drive out half of the air beneath it through an opening 12ft. by 6ft. Allowance does not appear to have been made for the fact that the time of the fall would be prolonged by the resistance of the air beneath, which would be enormous if the air were to be, according to the hypothesis, compressed to such an extent as to raise its pressure from, say, 14lb. to 35lb. per square inch, for a resistance of only 28lb. per square inch would balance a mass of rock of at least 24.6 feet in height. The hypothesis, the Commission added, even if it be possible, is certainly grossly improbable. Mr. Leitch, who was under-manager of Mt. Kembla up to six weeks before the disaster, gives the area which remained to fall as only 1242 square yards, not 44 yards square as assumed by Dr. Robertson. This would be quite insufficient to develop the energy requisite to support the wind-blast theory. Moreover, experience shows that the rock would not fall in a solid sheet, but rather that it would crack and break up in numerous pieces.

As to the evidence of heat; eye-witnesses saw flame burst from the mine, and this is supported by the microscopical and analytical examination of the coal dust taken from various places, chiefly from the No. 1 Right Main Engine Road. These show visible signs of coking, and taking the average Kembla coal to contain 23 per cent. of volatile hydrocarbons, the loss of this hydrocarbon due to distillation varied from 4.09 to 56.35 per cent. Mr. Mingaye, analyst and assayer to the Department of Mines, concludes that the particles had been subjected to a flame at a temperature represented by a cherry-red heat, 700deg. to 800deg. Fahrenheit. Some of those witnesses who supported the wind-blast theory quoted the experiments made by Professor Bedson, who found that a mixture of coal dust and air would ignite at a temperature of 291deg. Fahrenheit; but it must be remembered that in these experiments the heat was applied gradually, so that there was time for firedamp to be distilled from the very fine dust before the actual ignition took place; then, even if one supposes 291deg. Fahrenheit was attained by the sudden compression of air to 35lb. to the square inch, which is highly improbable, the condition not being the same, they cannot in fairness be compared. Besides, the indications are that the ignition of an inflammable mixture of firedamp and air took place about the junction of the 4th Right Rope Road with the No. 1 Right Main Level, and there being two openings at this point, any heat resulting from compression would be very greatly lowered by re-expansion The Commission, after carefully weighing all evidence, came to the conclusion that a fall in the 35-acre waste drove an inflammable mixture of firedamp and air down the 4th Right Rope Road to the No 1 Right Main Level with sufficient force to cross the Travelling Road without distributing itself in that road to any great extent. The mixture driven into the Main Level, with a tendency to travel rather outbye than inbye, owing to the angle at which the 4th Right meets that road, met the intake air current, which retarded its forward movement, so that its centre came to be about the 4th Right Junction. The northern extremity of the mass spreading inbye along the Main Level, reached a wheeler's naked light at the 4th Left, which sent a flash of flame back, communicating the ignition to the whole body, the explosion being made more violent by the presence of coal dust raised by the first blast. Thus the centre of force showed itself at the centre of the explosive body, and not at the point of ignition. The firedamp and air exploded, and in turn started a series of explosions of coal dust in such quick succession as to be practically one instantaneous explosion, receiving fresh accessions of force as it reached fresh supplies of oxygen in the air-courses traversed. These explosions of firedamp and coal dust generated a large

quantity of carbon monoxide, which is the deadly constituent of afterdamp, and caused the death of most of the victims.

Not only had firedamp been found generally in this colliery, but at the Bulli colliery, a few miles away, working the same seam, a somewhat similar disaster had previously taken place. The mine was dry and dusty, but there were no proper watering appliances for laying the dust. The dusts of different coals vary in the degree with which they ignite, and the force of the resulting explosion. That of Mount Kembla had a relatively high explosive force, and according to the tests made at the Home Office Testing Station, Woolwich, in 1901, the dust was described as "violent explosion" on each occasion. Still, in spite of this, naked lights were used in the mine, and the ventilation was actuated by a furnace at the bottom of the 400ft. deep upcast shaft. Fortunately, this furnace was not damaged, so as soon as the blast had exhausted itself, the ventilation currents returned for the most part to their usual channels, except where the roads were blocked by falls of roof, and as each tunnel was an intake, the rescue parties were able to follow up as the afterdamp was drawn to the upcast. The deadly afterdamp, as is usual in most colliery explosions, accounted for most of the deaths. This insidious gas has its danger intensified, inasmuch as it cannot be seen or readily smelt or tasted, neither does it extinguish a burning light like carbon dioxide, for it is combustible. It is an accumulative poison, as little as half to one per cent. proving fatal. It has a greater avidity for the hæmoglobin of the blood than oxygen, and, by combining with it, forms a bright red compound, known as carboxyhæmoglobin, which gives to a corpse a life-like healthy appearance. When the blood takes up about 50 per cent. of saturation a man begins to lose power over his limbs, at 79 per cent. he dies. The process of recovery from carbon monoxide poisoning is very slow and painful, and a patient may die several days after having inhaled it. When entering a mine after an explosion, rescue parties should carry cages containing white mice. Any small warm-blooded animal would do, but white mice are easily tamed, handled and seen. Carbon monoxide reacts on a mouse twenty times more rapidly than on a man, as its heart beats so much quicker. As afterdamp is lighter than the ordinary atmosphere, the cage containing the mouse should be held above the head. When the mouse shows symptoms of being poisoned, the men have time to escape. Ventilation by furnace is not so efficient, for the amount of fuel consumed, as by fan; neither is it so regular, as the coal is fed intermittently. There is, besides, always the element of danger when using furnaces in a colliery where firedamp is given off, though the risk may be reduced by taking air for combustion from the in-

take, and allowing the return air from the workings to pass into the upcast shaft through a dumb drift or airway that commences at a point inbye from the furnace; it then inclines towards the shaft, which it enters at a point sufficiently high above the furnace to prevent the ignition of the firedamp. The amount of ventilation produced by a furnace varies as the square root of the difference in temperature of the intake and upcast. It is a mistake to think that coal costs nothing because it is won in the mine that uses it; for the coal could be sold if not used; therefore, it should be debited to the cost of ventilation at the current market price.

The Mount Kembla colliery owns an area of 8,700 acres, of which about 1200 acres have been worked out. The output is about 1100 tons per diem; but fell off during 1907. Towards the south, where the seam is thin, about 2ft. 10in., the coal is worked by the longwall system; but where the seam becomes thicker, the bord and pillar method is used. Rolls occur in the seam, but are not so high as at some other collieries in the district, so do not interfere to the same extent in the direction of the roads, or with the shape and size of the pillars.

Oil from shale was first produced here in 1865, but operations ceased within about a year. In 1874 the property was sold to the Mt. Kembla Coal and Oil Company, who worked the shale for some ten years, and then left off owing to unremunerative returns. According to official figures, approximately 8711 tons of shale have been won from the Mount Kembla deposits.

The large coal is shipped from Port Kembla, seven miles distant from the mine. Some smalls go to Sydney for use at the Power House, and some coal is used locally for coking purposes. Since the disaster they have had to work more of the thinner portion of the seam. The coal won produces more ash per ton than that obtained from the thicker portion; also the coal contains less bituminous matter, so requires greater heat to coke it.

Two types of coal-getting machines are employed at this colliery, both driven by electricity. The Goodman chain breast machine is used in the bords; while Hurd's pick-quick machine is employed for longwall work. The Goodman variety of machine is that known as the "low vein," and is only nineteen inches in extreme height; it is capable of giving 6ft. depth of undercut for a width of 3ft. 9in. It is practically the "standard machine" modified for work in low seams. The machine shown in Fig. 149 differs slightly from that at work in the Mount Kembla mine, for the latter has rollers on either side at the motor end, so that the machine can be more readily shifted sideways for a fresh cut. The motor is enclosed in a perfectly flame-proof cast-iron casing.

The cutter is conveyed along the headings in a plain drop-end truck drawn by a horse.

The pick-quick (Fig. 150) is a bar machine constructed for longwall work, for which purpose it is used in the thin portion of the seam at Mt. Kembla. At this colliery the pick-quick machines are direct current. flame-proof, mounted on stands, and can undercut 4ft. 6in. deep, the height of the cut

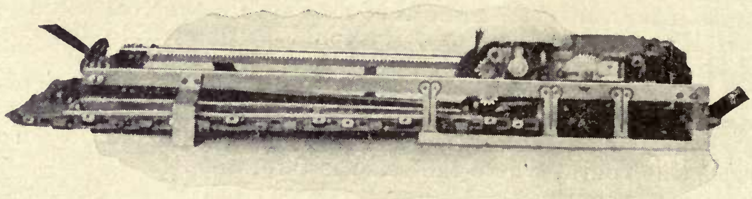

Fig. 149—"Goodman" Low-vein Electric Chain Breast Machine.

being from 4in. to 5½in. The gearing between the motor and the bar is 2 to 1. Owing to the small diameter of the bar, and the fact that it is close to the coal, it is less likely to be jambed by the coal should the latter be tender, than other types of coal cutters; also props can be set under the coal closer than with, say, a disc machine. The bar is a tapered rod with a spiral thread formed on it;

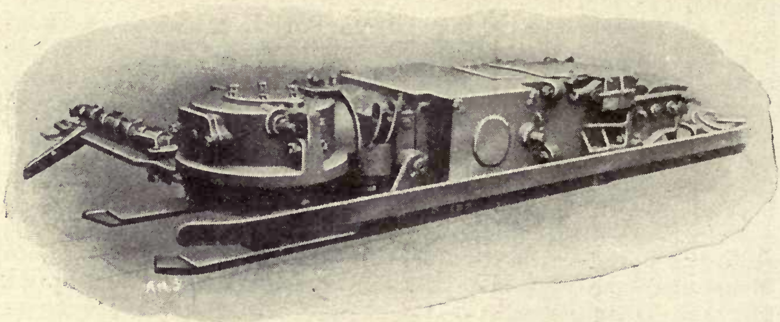

Fig. 150—The Pick-quick Direct-current Cutter on Skids.

the cutters are arranged in the space between the thread. The cutter picks have tapered shanks, and a feather is formed on one side so as to fit the tapered and seated holes in the cutter bar. For cutting in coal, the cutters are shaped to a point; for cutting in slate, they are dressed to a chisel shape, ⅜in. wide. The cutters must project a uniform distance above the

thread of the bar. The thread and cutters may be arranged with a left or right spiral, according to the direction it is desired to work in; but in either case the bar must be rotated in the proper direction, or else the coal cuttings will not be filled out. The bar has a rotary and reciprocating movement which gives a chipping and shearing action, and prevents the bar from clogging, and the cutter bar from working in a groove. The spiral thread round the bar acts as an Archimedean screw and conveys the cuttings away in a continuous stream. If the coal was not got rid of, it would pack into a hard mass, which would have to be loosened by hand. A cleaner-bar is placed 4in. behind the cutter, which scrapes the cuttings close to the cutter bar. This machine works well in coal, but the cost of repairs is considerable when cutting into rock or pyrites. Two men are re-

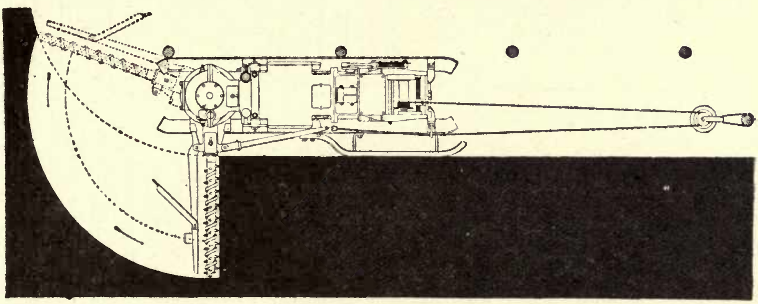

Fig. 151—Starting a cut with the Pick-quick.

quired for each machine. The bar can move both vertically through an angle of 20deg., and horizontally for 180deg. For good floors, skids are better than wheels, for it saves the cost of track-laying, which, when the machine works fast, is difficult to do quickly enough. On skids the machine runs smoother and with less vibration than on wheels; the machine also cuts closer to the floor. The power required to shift the machine on skids is not so very great, as it is exerted relatively slowly. When starting a cut the bar lies horizontally in line with the face of the coal; the bar is then revolved and carried to line on its horizontal axis, as it cuts into the coal, until the bar is at right angles to the track; it then continues to cut the coal as the whole machine is pulled forward (Fig. 151). The machine is self-propelling. A longwall machine may be worked so that it always cuts in the same direction, and on reaching the end of the face it is flitted back to its starting point along roadways; or it may cut to and fro across the face. The first method is generally em-

ployed, especially when the face is long, and two or more machines follow each other. Where the roof is strong there is a temptation to increase the length of the face, so as to reduce the cost of flitting per ton of output; where the depth of cut and thickness of seam yield a large output, the cost per ton for flitting is very insignificant. When working the machine to and fro, it has to wait before starting again till the coal is cleared away.

Three endless ropes pass into the main tunnel, one in the middle and one on either side for two districts. Near where the rails branch off, the side ropes pass through forks which work the switches when struck by the clip attached to the skips. The mechanism of this automatic arrangement may be seen by referring to Fig. 152. A wrought-iron plate

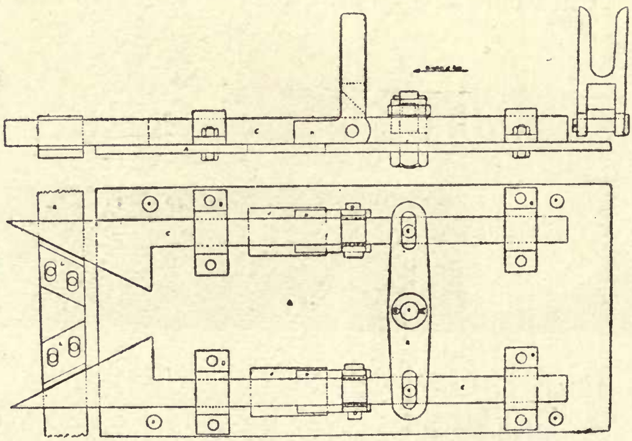

Fig. 152—Automatic Switch.

(A) is bolted through the holes (B) to sleepers between the rails. On this rest two bars (C), each having a triangular-shaped head; the lateral motion of these bars is limited by the staples (D) arranged near their ends. The two bars (C) are connected by means of the lever (E), which is secured to the plate (A) by the stud (F), on which it can turn. Studs (G) are screwed into the bars (C), which fit into slots cut in the lever (E). The fork (H) when struck by the clip, pushes (C) forward and drops out of the way of the skip into the rectangular hole (J) cut in the plate (A). The bar switch (K) has two angle irons (L) secured to it for adjusting the travel of the switch. The clippers-on, by attaching an empty skip to the rope of the district for which it is intended, are able to feed whichever district they desire from the entrance of the tunnel, without further trouble; for when

the clip strikes its fork, the bar to which it is connected is pushed forward, the triangular head pushes against the angle-iron attached to the bar switch, and directs the skip on to its proper rails.

The coal is screened near the mouth of the tunnel, after which it is conveyed in hopper waggons down a gravity plane, one at a time. At the bottom, the waggons are collected to form a train which is then drawn by locomotives to the main line, or the jetty. The self-acting incline has three rails above and two below the pass-by. The waggons are lowered down the incline from two drums on one shafting; one rope passes over, the other under its drum, and the speed is regulated by a brake operated from a steering wheel.

The hopper waggons, instead of being drawn by horses, as is usual, between the brow of the incline and the screens, are attached to an endless rope that circulates on the outside of the incoming and outgoing pairs of rails. A chain is hooked on to one side of the waggon; at the other end of the chain is a long-handled clip, which is made to embrace the endless rope, and is held by the man in charge as he walks along and keeps it pressed against the rope so as to ensure a good grip. The clip can be readily detached at any point; and, as the waggon does not get any great way on it, it is easily stopped under any of the sliding doors fixed to the bottom of the coal hoppers, or at the top of the incline, as the case may be.

Mount Kembla is following the lead given by South Bulli and Bellambi, and is taking steps to instal an up-to-date electric power plant. This is being provided by Noyes Bros., of Sydney, and when complete will consist of a 220kw., 2200 volt, three phase British Westinghouse alternator, with belted exciter, coupled to a Belliss and Morcom high speed engine, running at 375 revolutions per minute and capable of developing 365b.h.p. with 140lbs. of steam at the engine's stop valve. A motor generator set, consisting of a 55 b.h.p., 200 volt, 710 r.p.m., British Westinghouse slip ring motor, belted to a 40kw. British Westinghouse 500 to 550 volt, compound wound, direct current generator. A 55 h.p. 200 volt, 710 r.p.m. British Westinghouse motor, for driving a 500 volt, direct current, surface generator, also two 40 h.p., 220 volt, 710 r.p.m. haulage motors.

The alternator is already erected on the slope close to the mouth of the tunnel. From there the power is carried into the mine through three core paper insulated, lead sheathed, and steel taped armoured cables, manufactured by the Callender Cable and Construction Co. Ltd., of London. The cables are buried direct in the ground. The total distance of high

tension transmission will be about 2½ miles. On account of the extent of the workings in this mine, it was found necessary to adopt the high tension system, which will admit of one of the motor generator sets being placed about two miles from the mouth of the tunnel. This set will supply current to the various coal cutters along the faces with very little loss in voltage.

The Mount Lyell Coke Works.

These works, which are under the management of Mr. Tuxworth, are located at Port Kembla. They consist of 62 rectangular ovens, 24ft. long, and 3ft. wide at the ram end. The walls are 5ft. 9in. high, and the spring of the arched roof 7in. These ovens, and those at Bellambi, belonging to the Broken Hill Proprietary Company, are the only ones with side and bottom flues; there are two flues in each wall, and two under the bottom of each oven, along which the gases circulate. Instead of generating heat by burning the coke of the oven, the heat derived from the combustion of gases is utilised. Greater care is required in the admission of air to coals which contain just a sufficient amount of volatile hydrocarbons, than those with an excess of volatile matter. A maximum yield of coke cannot be expected unless one has the best conditions for retaining the heat, and a perfect regulation of air. The coke is quenched in the oven by spraying water on it through a loose perforated pipe connected to a hose. It could be partly or wholly quenched outside the oven, but the cloud of steam given off would retard operations. An hydraulic ram is used to push the coke out on the coke wharf. The doors of the ovens are raised and lowered by a small overhead hydraulic ram, one on either side of a battery of ovens, which can be run along into position where required. The coal for coking is obtained from the Mount Kembla colliery.

Wonga Willi Colliery.

This property is being opened up by a local syndicate. It is situated opposite Dapto, and is the furthest south of any colliery in the Southern Coalfield, now that the South Kembla Colliery (which was formerly worked for about three years) is abandoned. The Wonga Willi has only recently started, so is still in the developing stage. The seam worked is not the Bulli seam operated by the other South Coast collieries, but what is known as the "thick" or "dirty" seam, which is about 15ft. thick, and consists of several small seams. Only about 5½ft. of the best of it is extracted, and even this has several bands in it. This seam is below the "four-foot seam," which is, again, under the "Bulli" seam.

CHAPTER XV.

The Newcastle Coalfield.

The principal collieries of the Northern District work seams either in the Upper (Newcastle) coal measures, or the Lower (Greta) coal measures. There are, however, minor collieries working in the Middle (Tomago) measures, near East Maitland. In the Newcastle measures, the Wallarah or Bulli seam is worked in the Wallarah colliery. The Great Northern seam is worked in the Pacific, Northern Extended, and Rhondda collieries. The Fassifern seam is worked in the Northumberland colliery. The Burwood or Victoria Tunnel seam is worked in the Ebbw Vale and Waratah collieries. The Young Wallsend seam in the Young Wallsend colliery; and the Borehole seam in the Lambton, Maryland, Co-operative, Wallsend, Duckenfield, New Winning (A.A. Co.), Hetton, Newcastle A. and B., Seaham No. 1 and No. 2, West Wallsend, West Wallsend-Killingworth, Teralba or Borehole, Dudley, Burwood, Lambton B., and Burwood Extended collieries. The first five mentioned as working the Borehole seam are outcrop collieries. The Yard seam produced good coal, and was formerly worked near Newcastle, but is no longer mined. The Dirty seam has no commercial value at present, so is not worked.

The Borehole seam, from which most of the coal in the Newcastle district has been obtained, besides the so-called "penny bands," have two well-known bands of inferior clayey coal running through it. The upper one is known locally as the "morgen," and the lower as the "jerry." At the A.A. Co.'s Sea pit, the upper part of the Borehole seam is separated from the lower portion by a band of clay shale, 5 to 8in. thick. As the seam goes west, this band becomes thicker, splitting the seam into two. The upper portion is called the Young Wallsend seam, and the lower part retains the name of the Borehole seam. At the Sea Pit, the Young Wallsend portion is 3ft. thick, and the Borehole seam 16ft. 5in. At

the Stockton colliery, both seams were in most cases taken out; stone drifts being driven to the top seam, and care being taken to leave the pillars of the lower seam directly below those of the upper; but further west, the distance between the seams being greater, each seam has to be worked separately. About the Wallsend and Co-operative collieries, there are 60 to 70ft. between the two seams. In some places the Young Wallsend is too dirty to work. The Young Wallsend colliery is the only place where it has been worked, and here it is 47 to 60ft. above the Borehole seam. At Duckenfield, the Young Wallsend seam was tapped on the boundary of the Young Wallsend colliery, where it was found to be thin and dirty. From there to West Wallsend, Seaham, and Killingworth, the lower seam improves; the jerry of the other collieries entirely disappears, and the coal rests on the Waratah sandstone, the true floor of the Borehole seam, which is used as a building stone in the Newcastle district. At Seaham, the two seams are 20ft. apart; at Killingworth they are only divided by 3ft.; the Young Wallsend seam being 10ft. 7in. thick, and the Borehole seam 8ft. 3in. At the Northumberland colliery, the two seams are 60ft. apart. At the Pacific, the Young Wallsend seam is 9ft. 10in., separated by 52ft. 2in. of rock, from the Borehole, which is 4ft. 9in. thick. Proceeding south from the Sea pit, towards Burwood and Lambton B. collieries, the Borehole seam becomes thinner, 5ft. 3in. to 5ft. 6in., and west of these collieries, at Teralba, there are only 3ft. 6in. of workable coal.

Backs and facings are very well defined in the Newcastle coal, and influence the mining. Dykes do not occur so frequently as they do in the Southern coalfield. The dyke-rock has not yet been determined, as it is so altered; but it is of a basic nature, probably basalt. Crushes have occurred at the Hetton, Stockton, A.A. Company, and Wickham and Bullock Island collieries. In the case of the latter, an area of 70 acres was affected, but no water was admitted to the workings.

The Stockton, Hetton, New Winning or Sea Pit, of the Australian Agricultural Company, the A and B pits of the Newcastle Coal Mining Company, and also the Dudley Coal Company, have all worked beyond high-water mark. The Scottish Australian Mining Company also intend to work coal under the ocean from their Burwood and Lambton B. pits.

A. A. Atkinson,* the New South Wales Chief Inspector of Coal Mines, says that due consideration should be given

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*Working Coal Under the River Hunter, the Pacific Ocean and its Tidal Waters, near Newcastle, in the State of New South Wales (T. I. M. E., 1902).

to the following matters in connection with the safe limit of working coal under the ocean:—

(1) Character of the overlying strata, with special reference to loose deposits of alluvium or beds of clay between the bed of the ocean and the coal seam.

(2) Presence of faults and dykes in the strata.

(3) Dimensions of pillars to be left and the width of openings to be made, or, in other words, the percentages of coal to be left and worked respectively.

(4) The utility of leaving coal next to the roof in some cases.

If there is a considerable bed of clay between the body of water overhead and the solid rock, this will tend to fill up any joints and cracks, thus stopping infiltration. Should there be, however, no clay, but only sand or shingle, then such a stratum of loose material would be as bad as if the water itself were immediately above the solid rock.

After proving the presence of faults and dykes, since the strata in their vicinity are disturbed, any passage approaching them should be reduced in size as much as possible, and a pillar of coal left next to the fault or dyke, the size of the pillar depending on local circumstances. The main point in working coal under large bodies of water is to lay bare as little as possible any fault or dyke met with. When working under tidal waters or under the sea, the minimum width of pillars allowed is 8 yards, and the maximum width of bords or other excavation is 6 yards. The 8 yard pillars must remain unwrought. The coal workings must be carefully surveyed every three months, and a record kept of all dykes and fissures met with. In one road of every pair of winning-off or leading headings, a bore shall be kept going 10ft. in advance, for the purpose of foretelling the presence of any fissure, washout, open joint, fault, dyke, or otherwise, and all winning-off headings shall be driven at least 50 yards in advance of the working bords, when under tidal waters; or 100 yards in advance in the case of working under the sea. Coal under the ocean should not be attacked until after a large goaf has, if possible, been made by extensive coal-workings under the mainland. The amount of cover of solid rock between the coal seam being worked, and the body of water overhead must be at least 120ft. The most accurate and trustworthy information should be obtained, not only of the depth and character of the sea bottom, but also of the strata overlying the coal seam, which strata must be bored through, and proved to have a minimum thickness of 30ft. at the face of the leading headings as soon as they have been driven 100 yards in advance of the working bords. After the first borehole has been completed, other boreholes must be put up in advance of it at

the face of the headings at distances not exceeding 20 yards. The A.A. Company has decided not to work coal under a less cover than 140ft., while the Stockton and Hetton collieries have a thickness of rock overhead of 250 and 300ft. respectively. The boreholes are generally made by a machine with a serrated steel bit, which gives a 1in. core. Boreholes 30ft. long generally cost about 2s. per foot. Where the roof is bad and the coal thick and tender, leaving some coal next to the roof has been found to have a strengthening effect.

On account of the unconsolidated alluvial material, often heavily charged with water, found near the surface at the site of certain shafts, such as at the Hetton, Wickham, and Bullock Island, and Stockton collieries, the ground had to be secured by means of cast-iron tubbing. In the case of the Stockton No. 3 shaft, this tubbing was continued to a depth of 281ft.

The greatest distance driven under the ocean off the New South Wales coast up to date for coal winning purposes is from 48 to 50 chains. It is most important that the sea should not be allowed to break into a colliery, for not only would the workings of that particular colliery be flooded, but those of any adjoining colliery to the dip which might be connected with it. Such an accident did actually occur on a comparatively small scale on 18th March, 1886, when the Ferndale colliery and about 20 adjacent small collieries were inundated with sea water and sand from a tidal stream named Tighe's Creek, and adjoining swamp, and irretrievably lost.

The Wallarah Colliery.

This colliery, situated at Catherine Hill Bay, is the southernmost colliery of the Northern coal field. Other properties have been taken up still further south, but, so far, only boring operations have been carried out on them. Originally this property belonged to another company, who worked a lower seam than that now operated on by the present company. The seam was attacked from a mine a few yards south of the jetty, but being dirty coal, it was eventually abandoned. The Wallarah Coal Co., an English corporation, took the property over about nineteen years ago. Mr. Joseph Sperring came out from England at that time, and acted as under manager till ten or eleven years ago, when he was appointed manager. The seam at present being worked averages about 12ft. 6in. thick, but only 6ft. of the bottom coal is worked. Both the top coal and the rock above make a good roof.

Two districts, known respectively as the "B" and "E," are now being worked. Both are approached by

means of tunnels. "B" is the older and "E" the newer pit, and most of the plant is situated at the mouth of the latter. The underground workings of the two pits are connected. The haulage at both pits is an engine plane, but at the "E" pit they are preparing to instal the endless-rope system for the main haulage, though the engine-plane will still be used for the first section, where the roadway is considerably curved. A set consists of 15 skips. The rollers to support the rope between the rails are of iron bark timber, turned with a shoulder at either end, which supports one edge of the iron rings that bind them, while nails on the outside prevent the rings from coming off. About 60 strong horses, from 14 to 15 hands high, are employed at the mine.

The coal is worked by bord and pillar. Bords worked by pick are 8yds. wide, the pillars between being 12yds. wide;

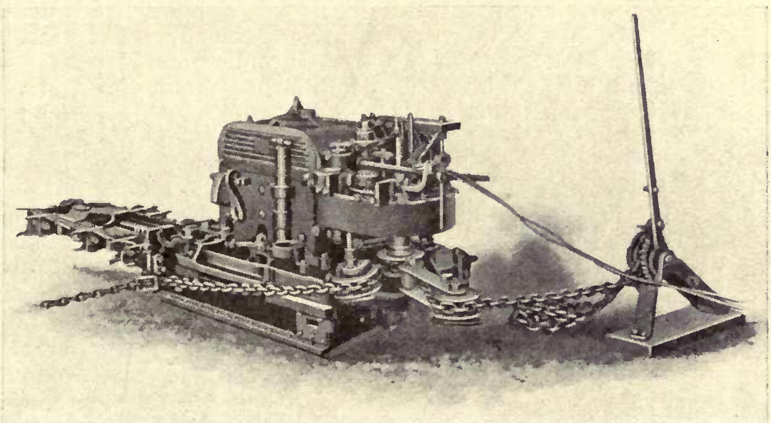

Fig. 154.—Sullivan Electric Chain Machine, showing "pan" detached and in position for starting a side cut across the face.

but those worked by machines are 12yds. wide, and the pillars between 14yds. Very little pillar extraction has been carried out, as there are so many places on the surface where water flows, and the workings being shallow, should the roof cave in, the amount of water admitted to them might cause considerable inconvenience and expense. Since there was some divergence of opinion as to which was the best class of machine to employ for coal cutting, different mines favouring the particular type they had adopted and were accustomed to, at this colliery, four kinds of coal cutters were tried, namely,

the Sullivan electric chain machine, the Jeffrey chain breast machine, the Jeffrey short wall coal cutter, and the Goodman chain-breast machine.

The Sullivan, Fig. 154, is heavier, and requires more power than the other machines. First of all the main pan is jacked against the roof to prevent it from working backwards; the machine is then worked forward off the main pan, at the same time putting in the sumping cut. When the machine is completely on the front pan, the two pans are disconnected, and the main pan drawn out of the way. This enables the machine to work in less space than ordinary chain breast machines, and therefore it does not interfere to the same extent with the props. The chain along which the machine pulls itself is anchored at the far side of the bord and jacked at the other. The anchor consists of a short piece of plate iron bent in such a way that one end digs into the pillar while the other end digs into the floor. A hook is connected to the plate, and to this the chain is fastened. Being out of the way, it does not interfere with the machine cutting close up to the pillar. When the machine has made the sumping cut 6ft. deep, it then cuts sideways for the width of the bord, sliding on a rail placed near its forward end. This leaves the back clear for a man to shovel the cuttings brought out by the picks. When a cut has been completed, the machine is placed on a trolly and drawn by a horse to another bord. Each machine requires three men: one to drive it, another to shovel away the cuttings, and the third to shift the rails, lubricate and generally to assist. The trailer cable is clipped to the main cable, the bare wires at the junction being covered by a rubber sleeve.

The old type of Jeffrey machine, as also the Goodman chain breast machine, work intermittently. As each cut is only 2ft. 9in. wide, when the full depth of the cut has been made, the machine has to be withdrawn and moved sideways for a fresh cut. The new type of Jeffrey machine (Fig. 155) works right across like the Sullivan, but instead of a chain two flexible galvanised iron ropes are threaded through the machine and anchored at either side of the bord; one is to pull on, the other to keep the machine straight on its course. This machine makes a cut 6ft. deep, and is found to do excellent work. When flitting from one place to another, it is mounted on a self-propelling trolly. All the coal cutters are driven by electricity. It is found advisable to have a large number of coal cutting machines, even if they are not all in use at once, for though when at work a machine may cut 20in. per minute, it takes so long to shift the machines about that the average is reduced to about 5in. per minute. It is found when working machines on the tonnage rate that the men

will not stop for repairs unless absolutely obliged to do so, but say the machine will last their shift, and pass it on to the next party in that condition. The following shift does likewise if possible. The result is that the machines do inferior work, and there is a tendency to wear the machine out quicker.

Ventilation is carried out by means of a 16ft. Walker's indestructible fan. This is driven by ropes from one of Walker Bros., of Wigan, engines. A duplicate engine is arranged end on to the other, which is used when repairs have to be undertaken. There used to be seven pumps driven by Petter petroleum engines, but now only two are in use. There are also three small electric three throw pumps, used for dip workings, and one Aldrich electric pump, made at Allentown, U.S.A., also a steam pump, which will soon be replaced by a

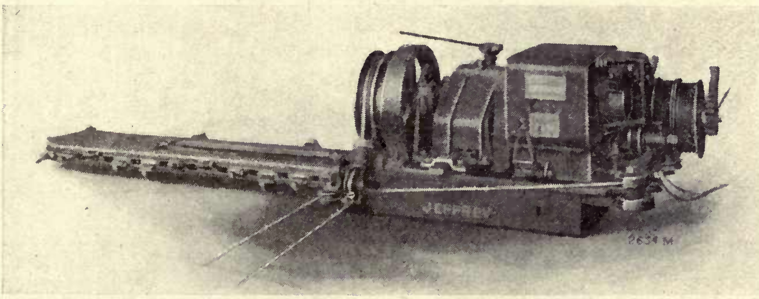

Fig. 155.—Jeffrey Shortwall Coal Cutter.

main electric pump. The vaporiser of the Petter petroleum engine is first heated by a simple form of paraffin blow lamp for five to ten minutes, after which the oil tap is opened and the fly-wheel turned by hand (Fig. 156). This causes the piston to move forward, and at the same time draws in a charge of air and oil through the upper valve. The piston then returns and compresses the mixture into the back part of the vaporiser, the oil having by this time become converted into vapour or oil gas. The mixture explodes with the heat, and drives the piston out with considerable force. At the end of the outward stroke the lower valve commences to open and the piston returns, expelling the burnt vapour through the exhaust pipe. The oil flows through a copper pipe to the governor valve. This valve controls the supply of oil to the engine, permitting more or less to pass as the load on the engine varies, and is so constructed, that if from any reason the engine should stop or the governor band break, the oil

would be instantly cut off. The governor lever, which is controlled by a centrifugal ball governor, rises and falls according to the speed of the engine, and as it does, it opens or closes the graduated oil inlet valve, and also at the same time a throttle on the air inlet, thereby providing for the exact proportion of oil and air being maintained whatever the load on the engine may be. The absence of a continuous burning lamp entirely eliminates all danger of fire arising from inflammable material coming in contact with a naked flame. The Petter engine has an automatic tube ignition contained in a small box attached to and forming part of the exhaust outlet of the engine. The tube, which is made of a special

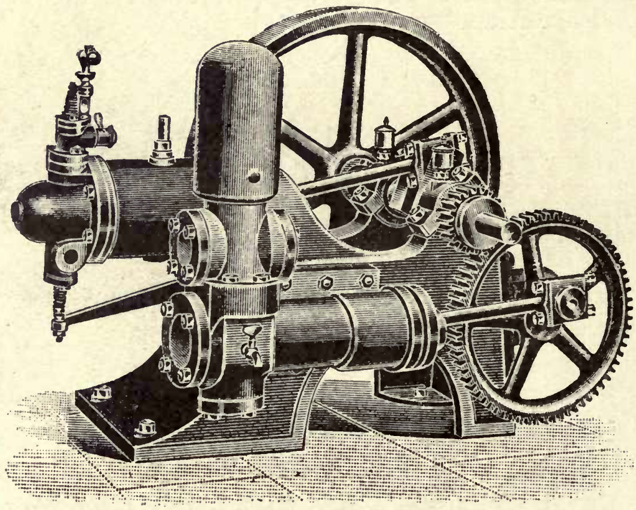

Fig. 156.—The Petter Petroleum Engine and Pump.

alloy, becomes red hot after the engine has been working for about five minutes, and thereafter performs the duty of igniting the vaporised oil and air. Being enclosed in a box, and protected from the cool outer air, these tubes last very much longer than those used in other types of engines. Under ordinary conditions three-quarters of a pint of oil is used per b.h.p. per hour.

The Aldrich electric pump (Fig. 157) in the "B" tunnel has 5in. diameter plungers, 6in. stroke and a capacity of 100 gals. per minute. The motor that drives it revolves between 500 and 1000 times per min., and is 7½h.p. The original electric plant consisted of a multi-polar generator built by the Goodman Manufacturing Co., of Chicago (U.S.A.) for 275

volts, 360 amp., with 250 r.p.m. and generating 100kw. This was driven by one of McEwen's engines rated for 187h.p., supplied with a Begtrup inertia governor (Fig. 158). A long bar called the inertia bar, with weights at each end, is pivoted at the centre on a roller bearing to an arm of the governor wheel. At the centre of the bar is a short extension, which carries the eccentric pin. A heavy coil spring is secured to the middle of one end of the bar, and on the other end is an

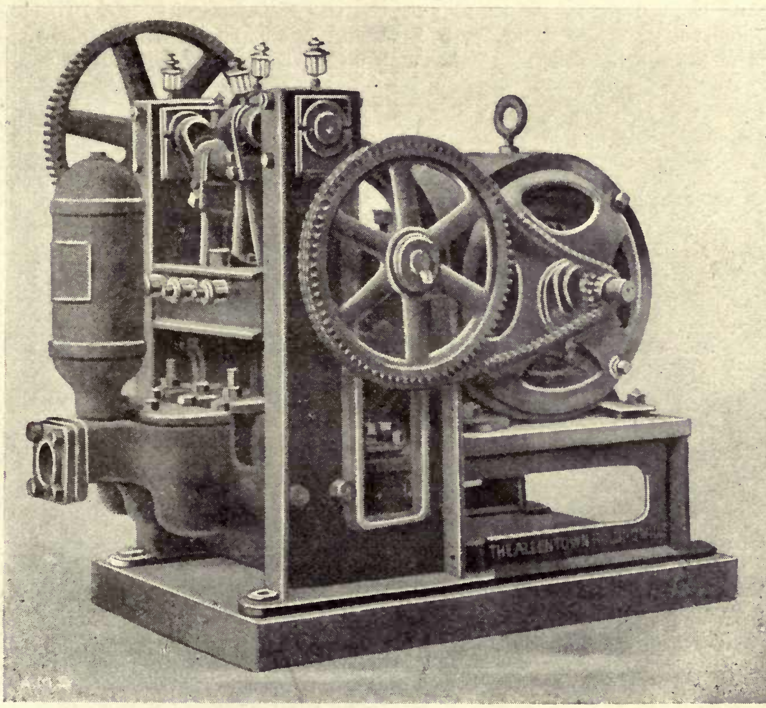

Fig. 157.—The Aldrich Electric Pump.

air dash pot, which consists of a cylinder with a loose-fitting piston, and connecting rod bolted to the inertia bar. The weight in the spring end of the inertia bar is the greater. Owing to the shape and relation of the various parts of the governor, the weighted end is so acted on by centrifugal force as to tend to swing it backwards towards the left hand stop. This tendency to move backwards is counterbalanced by the spring, the tension of which is such as to hold the inertia

bar in equilibrium at the desired speed. The motion of the governor shown is over from left to right. When starting up, the positions of the governor parts are as shown. In this position the eccentric pin travels in its greatest path, giving the valve its widest opening and latest cut-off. As the speed increases, centrifugal force, acting on the weighted end of inertia bar, moves it backwards towards the left hand stop, thereby reducing the travel of valve and cutting off steam earlier. This backward movement of the inertia bar is continued until the travel of the valve reduces the cut-off to just what is necessary to keep the engine rotating at the proper speed to give even balance between centrifugal force acting on the inertia bar, and the opposing tension of the spring.

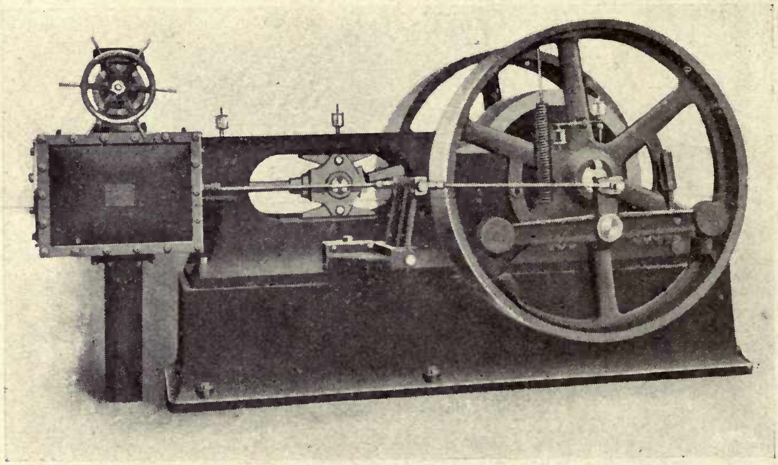

Fig. 158.—The McEwen Engine.

Should a load be suddenly applied to the engine there is a check to the speed of the governor wheel, while the inertia bar, by reason of its momentum, rotates forward sufficiently to increase valve travel, and give late enough cut-off to carry the load. Should the load be thrown off, the governor wheel tends to increase its speed, thus causing the inertia bar to swing backward and reduce travel and cut-off until equilibrium is established as before. It will be seen that in this way the speed of rotation under a steady load depends entirely on the equilibrium between the centrifugal forces on the inertia bar and the tension of the governor spring, while the actual movement of the governor parts is effected by the inertia of the weighted end. If the weights in the inertia bar

and tension of spring are so adjusted that the centrifugal force increases faster than the tension of the spring, then the engine will speed up under load. In this condition the engine is liable to race, and it is to prevent racing that the dash-pot is used. It is thus possible to adjust any engine so that it will run faster under load than when running light, and still regulate perfectly and with no tendency to race. On the other hand the governor may be adjusted to run slower under load than with no load. Perfect stability is obtained by the use of dash-pots; at the same time they increase the ease with

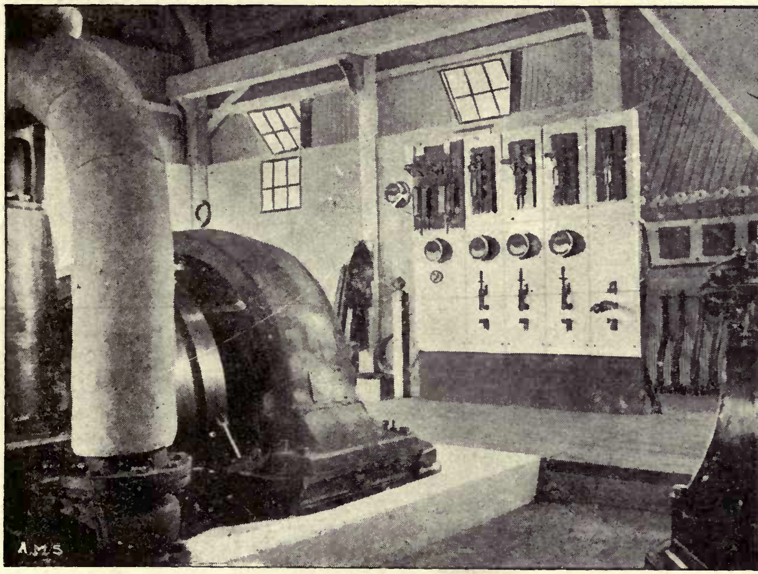

Fig. 159.—Wallarah Switchboard.

which adjustments can be made. No difficulty is experienced in adjusting these engines to govern within a limit of one revolution, and the instantaneous variation of speed when the entire load is thrown on or off is seldom more than one per cent., while the action of the governor is unusually quick. the engine returning to its standard speed within the space of two seconds.

The new electric plant was supplied by Siemen Bros., and consists of a direct current compound field generator, of 200 kw., 0-670 amp., 427-425 rev., and 270-300 volts. It is driven by a W. H. Allen, Son and Co. vertical compound engine with 13½ and 21in. diameter cylinders and 9in. stroke. It has 425

revolutions per minute, and high pressure steam of 140lb. is used. Marble switch boards, Fig. 159, are used for each unit.

Geipel rapidity type of steam trap for automatically removing condensed water in the steam pipes is used with this plant. These traps are suitable for both the highest and lowest pressures, and can be adjusted to act for a wide range of pressure. The valve is arranged in such a way that it is held on its seat by steam pressure, consequently a valve of a much larger area can be used than if the valve closed against steam pressure. The valve is of the rotating type, and is separate from the valve spindle, so is not held fast by the friction of the stuffing box. Being provided with vanes, it is caused to rotate while discharging, and consequently to grind itself in at each discharge so that the seat is kept in good order. There is no dribbling, but as soon as the trap commences to discharge, the valve is forced well open. A sharp blow through then occurs, until all water is discharged, when the trap

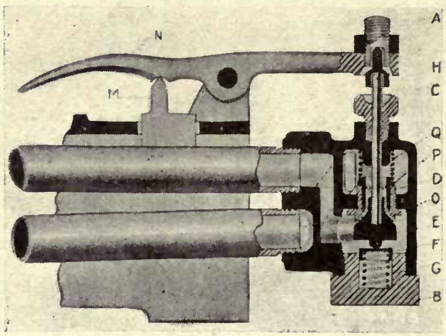

Fig. 160.—The Geipel Rapidity Steam Trap.

is suddenly shut. The trap consists of two tubes fixed at one end but free to move at the other, where the valve is situated. The upper or inlet tube is brass, while the lower or discharge tube is of iron. In Fig. 160 the valve E is held normally on a light spring G. When the trap is cold or full of water, the valve is depressed from its seat by the valve spindle C, which abuts against the end of the lever N. When steam enters the brass tube the latter expands and moves the valve casing O downwards. The steam pressure and light spring then close and hold the valve tight until water has again entered the brass tube and cooled it, upon which the brass tube contracts and moves the valve casing upwards until the valve spindle C impinges on the lever and forces the valve open. As soon as the valve is open the rush of water, so to speak, forces or wedges the valve downwards, thus making the large opening which gives the rapid discharge. So rapid indeed is the dis-

charge that an automatic throttling device has been found desirable at high pressures, in order to avoid shock, strains, and noise. This device consists of a movable bush P, controlled by a spring Q; its action is automatic, so that when the trap is discharging at low pressure, as for example when steam is first turned on, the bush does not tend to throttle, but when the pressure rises and there is an increased discharge, the friction thereof moves the bush in an upward direction against the action of the spring, thus reducing the aperture of the discharge and consequently its velocity.

Steam is generated at the E. pit by two Babcock and Wilcox boilers, and two Cornish boilers, made by G. and C. Hoskins, of Sydney. The Babcock and Wilcox boiler (Fig. 161)

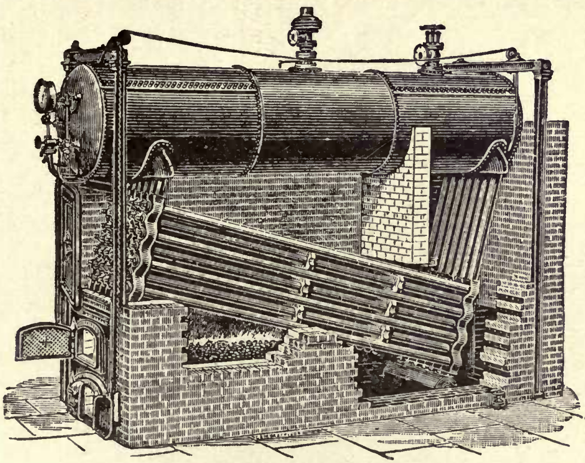

Fig. 161.—Babcock and Wilcox Boiler.

consists of a number of small steel tubes, which are set at an inclination, the higher point being over the grate. The ends of these tubes are connected by zigzag chambers termed headers. Adjoining headers fit closely together, and are so constructed that the tubes are staggered. The top of each header is connected by a tube to a collecting chamber, one of which is at each end of a horizontal water and steam drum, arranged overhead. There are openings in the headers opposite each water tube, which are closed by hand holes, the joints of which are made by accurate metallic contact. The tubes are lap welded, so there are no riveted joints, with their double thickness of metal in parts that cause undue strains, owing to unequal expansion. On account of the comparatively small diameter of the tubes, they possess a relatively greater

strength. The tubes are expanded into the headers, and all joints are kept away from exposure to the direct heat of the fire. The water and steam drum is of sufficient capacity to prevent any sudden fluctuation in pressure or water level. At the lower end of the inclined tubes, the bottom of the headers are connected by other tubes to a mud drum, which is removed from the action of the fire, and which receives the impurities deposited from the water. The boiler is suspended from wrought-iron girders, resting on iron columns entirely independent of the brickwork. This prevents any straining of the boiler from unequal expansion between it and the enclosing walls, and permits the brickwork to be repaired or removed, if necessary, without disturbing the boiler. The combustion chamber, built round the boiler has soot doors

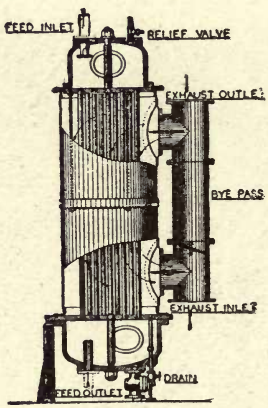

Fig. 162.—Babcock and Wilcox Feed Water Heater.

left in it, and the direction of the draught is controlled by a baffle wall built across it, so the combustion of the gases has a chance to be completed before coming away to the stack. The products of combustion from the grate rise up between the tubes into that portion of the combustion chamber below the steam and water drum. They then pass onwards between the tubes under the baffle wall and up between the rear end of the tubes towards the flue. The tubes, which are supported between their ends by fire brick distance pieces, divide the water into small volumes, which are quickly raised to a high temperature. The mingled steam and heated water rise upwards to the steam and water drum, where the steam separates and is drawn off in a dry state at the far end of the drum. The water flows to the rear and down the lower end of the

tubes; in this way a continuous circulation is caused. As the passages are large and free, this circulation is rapid, tending to make an equal temperature through the boiler, and being in one direction there are no interfering currents. The large water surface for the disengagement of the steam from the water prevents foaming. The water space is so divided into sections that should any section give out, a general explosion could not take place, but the destructive effects would be confined to the simple escape of the contents. With large and free passages between the different sections, the water line and pressure in all are equalised.

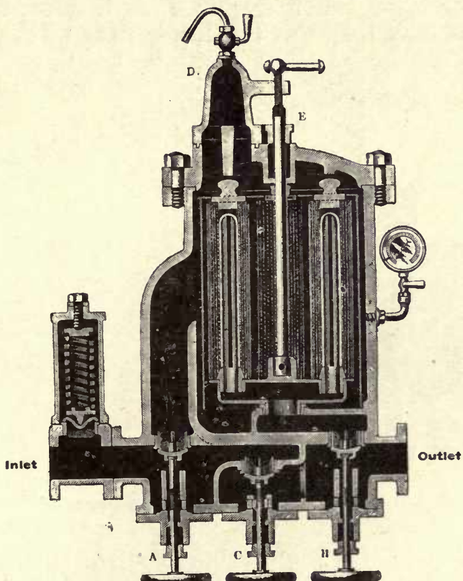

Fig. 163.—The "Sentinel" Patent Multiple Feed-water Filter and Oil Separator.

The exhaust steam is used to heat the feed water in one of Babcock and Wilcox feed water heaters. (Fig. 162.) The cold feed water enters a chamber at the top of the apparatus, and passes down a nest of tubes to a lower chamber, where the outlet pipe is raised above the bottom so as to be above any sediment. The exhaust steam enters the shell round the nest of tubes at the bottom, and escapes near the top.

A "Sentinel" multiple feed-water filter and oil separator is used. This apparatus, manufactured by Alley and Maclellan Ltd., of Glasgow, is effective and compact, has a large

filtering area, and is easily cleaned. Experiment has proved that the surface through which feed water is filtered should be at least 250 times the area of the feed water pipe. The filtering medium employed is cocoa-nut fibre, which has a great affinity for oil, and being of a porous nature four plies can be used round each mantle without fear of choking the filter. There are six mantles, each of which passes over a hollow support attached to a round table, which can be revolved by the spindle (E), Fig. 163. To pass the feed water through the filter, the valves (A and B) are opened, and the valve (C) closed. To pass the water direct to the boilers (C) is opened and (A and B) are closed. The drain cock is opened once or twice a day for a few seconds to blow out the heavy deposits that may lodge at the lower part of the filter. The

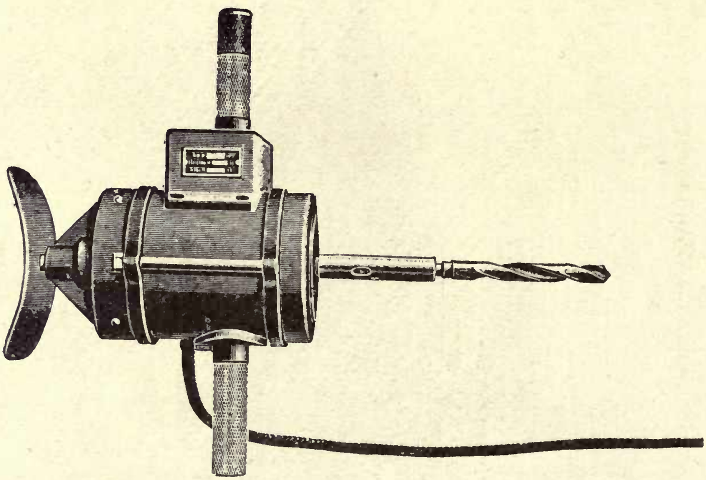

Fig. 164.—Portable Electric Drill.

scum cock on the top of the dome (D) is also opened occasionally to blow off the light impurities that gather on the surface. When the pressure gauge shows 20 per cent. above boiler pressure, it is time the mantles were cleaned or changed. In using this apparatus, before removing any of the filtering mantles, open the valve (C) and close the valves (A and B), run the filter dry by the sludge cock on the underside; remove the dome (D), and each mantle can be removed and a new one put in its place, as each tube carrier is moved round. To clean the inside of the filter, first open the valve (C) and close the valves (A and B), run the filter dry as before, fill it up with clean cold water, which can be done with a head of water through the sludge cock. Admit a little

live steam by a small cock on the side of the filter to boil the water for a short time, putting a little sulphate of ammonia or soda inside before starting; shut the steam off, remove the dome, and turn on cold water at the sludge cock, when all the oil and dirt which has been adhering to the inside body of the mantles and filter will overflow at the opening that the dome sits on. This operation performed about once a week will help to make the mantles last longer, especially when much oil is used.

The fitting shop contains two lathes and machines for shearing, punching, drilling, and shaping; the blacksmith's shop two forges, the air for which is supplied by mechanically-driven blowers; also a steam hammer. In the carpenter's shop is a band saw, drilling and morticing machine, and a lathe. In the waggon repairing shed, portable electric drills are used for drilling rivet holes in the plate iron. (Fig. 164.) These are convenient to handle, easy to take apart, and all parts being completely covered they are suitable for outdoor work. In comparison to their capacity and stability, they are very light. A saw-mill is in course of construction, and a spacious store has just been completed.

The jetty is lighted up by electric lights, from a Siemen Bros. 250-volt 0-20 amp., and 400-475 r.p.m. dynamo. The hopper waggons are drawn along the jetty to the four shoots by an endless rope of flexible galvanised iron driven by a two-drum winch. The rope passes over a vertical sheave at the shore end, and two horizontal sheaves at the ocean end. A vertical boiler supplies steam for the dynamo engine and winch. The waggons are weighed on a Pooley weighbridge near the jetty before being discharged into the ship's hold.

Pacific Colliery.

This colliery has, in different stages of its existence, been known as the Great Northern, the Northern, the Pacific Co-operative, and the Pacific. The total thickness of the seam is 19ft. 6in. In the first working, 7ft. 6in. is extracted; in the second working, 6ft. is taken out. Two feet of top coal is left, and 4ft. of bottom coal. The roof consists of a blue shale, or conglomerate, and the floor is a very fine sandstone. The seam is worked on the pillar and bord system, the pillars being 8 yards and the bords 12 yards wide, i.e., they are in the proportion of 2 to 3. Every eighth bord is made into a "ganning bord," or wheeling road.

The mine is worked from tunnels. First an engine hauls the skips for about half a mile along an engine plane, and then the main and tail rope system takes up the haulage for another half-mile. A drag-bar, consisting of a heavy, pointed iron bar, is connected with a shackle to the last skip by a screw

bolt, so as to prevent the train of skips from running down hill backwards, in case of accident. The engine plane rope is capped, a chain attached, at the other end of which is a hook, and fastened to the shank of this hook, is a link that passes over the tip of the hook, and is prevented from coming off by a cotter pin. The hauling engine is situated near the tunnel, and consists of a pair of 15in. diameter cylinders, with 2ft. 6in. stroke, and is geared two to one. The main and tail rope engine is a pair of 20in. diameter cylinder, with 3ft. stroke, and is worked with 60lb. pressure of steam. Steam is generated in one Lancashire and two Cornish boilers.

Ventilation is carried out with the help of a Guibal fan 32ft. in diameter, and 12ft. wide, with air inlet on one side only. When working the pit, it is given 30 to 35 revolutions per minute. The fan engine has a 24in. cylinder and 3ft. stroke; a spare engine in duplicate is arranged end on.

This is a colliery where machines are found to do cheaper work than men; and machines have a further advantage in lessening the number of men necessary to carry out the work, and requiring a better class of men. Also machines enable one to obtain a given quantity of coal out of fewer places than with pick work, so that operations are easier to supervise, and the colliery can be laid out accordingly. At the Pacific they have four Sullivan electric chain machines, but only two are worked at a time. These machines are worked 16 hours a day, i.e., during afternoon and night shifts, and produce about 700 tons for the two machines. A shift's work for one of these machines is 3 to 4 bords, averaging 3½ bords for 8 hours, as against 4½ tons per man, as was formerly the case when hand picks were used. When undercut, three men (a firer and two fillers) can handle 45 tons. Each machine has 33 picks, and on an average 40 to 50 of these have to be sharpened per day. Thirty horse-power is required for each machine. The motor was provided by the General Electric Company, and works under 250-volt pressure. It is driven by a Harrisburg Standard Buckeye engine, 13½in. cylinder, and 13in. stroke, controlled by a flywheel governor. The workings are drained by three double-acting Tangye pumps, driven by steam.

After screening the coal, the slack not required for immediate shipment is raised to a coal-box for storage, up an incline in a hopper skip. This hopper skip has a saddle-back across it in the centre, and on either side of this on the bottom is a sliding door. The skip is hauled up the incline over the coal box by a pair of 7in. cylinder, 15in. stroke, engines, geared 7 to 1: when the point is reached where it is desired that the slack shall be emptied, the doors are automatically opened, and the coal falls through.

Northern Extended Colliery.

This is one of the collieries belonging to the estate of the late Mr. Andrew Sneddon, and is under the management of Mr. D. Sneddon. It is situated near the Teralba railway station. The Great Northern seam is being worked, which is 15ft. thick; of this 12ft. 6in. is good marketable coal. At present they take out 7ft. 6in. of the centre coal. About 2ft. 6in. of bottom coal is inferior, so it is left in position. The top coal is also left till later on, as it is awkward to mine, being so high; besides, it helps to support the pillars, which are thus made relatively shorter. The seam is subject to swallows or depressions. These are fairly shallow, but the coal and included bands, also the roof and floor, are affected, which points to the irregularities having been caused subsequently to the formation of the coal, for otherwise the coal would have filled up the depressions in horizontal layers. The roof is conglomerate, and the floor a fine-grained sandstone.

The workings are reached by a tunnel or main dip. Eight or ten skips in a set are hauled up the roadways by direct haulage. A drag-bar shaped like a Y (Fig. 165) is

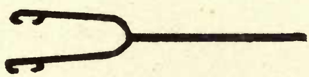

Fig. 165.—Dragbar.

hooked on to the back axle of the last full skip. The hooks on each branch are double, so when the point of the bar digs into the ground, it is not likely to become detached. This bar drags behind on the ground, but in case of a break-away, it sticks in the floor and overthrows the skip, thus avoiding a worse accident. Where the road goes to the rise a jig is used, the full skips as they descend drawing up the empties. In this instance, also, 8 to 10 skips go to make up a set. At the upper end of the jig, the pulley round which the rope passes, as also the band brake, are arranged in a frame let into the roof and floor. The skips are collected to the top of the jig by horses. On account of the height of the seam, heavy draught horses can be employed.

The winning heading to the dip is taken out in two workings on account of the water present. First the top portion is taken out as far as the position for the next bord; then the floor is lifted. The bords are made 8 yards wide, and the pillars between are 9 yards.

The coal is holed by machines—two Sullivan electric chain machines, and one Goodman standard chain breast machine, also driven by electricity. They both cut well. The Sullivan

makes a 6ft. deep cut for a height of 4in. The Goodman (Fig. 166) is more clumsy to move sideways, and requires more labour. It makes a cut 7ft. deep and 4ft. wide. The picks sometimes require to be changed two or three times a shift. None of the machines are mounted on self-propelling trucks. If the working places are close to one another, five bords may be cut across per shift. All the cutting is done at night when the roads are clear. Fig. 167 shows a man boring shot holes with a rotary boring machine. There are two electric pumps, a three-throw Worthington, and a centrifugal, both driven by motors provided by the General Electric Company. The air currents are induced in the mine by means of a furnace, the air

Fig. 166.—Goodman Coal Cutter on Trolly, Ready for Flitting.

passing over the fire, through the grate, and along drifts on either side. The amount of air circulated is 50,000 cubic feet per minute.

Steam is generated in a Babcock and Wilcox boiler. The motor is one of the General Electric Company's, built for 260-250 volts, 220amp., driven by a Harrisburg standard engine, controlled by a flywheel governor.

Rhondda Colliery.

The Rhondda Colliery belongs to Messrs. William Laidley and Co., and has been in existence for ten or eleven years, dur-

ing which time Mr. James Barr has been in charge. The seam being worked is the Great Northern, a section of which is shown in Fig. 168, but only the lower 7ft. 10in. are worked at present. The coal is not so good as that from the Borehole seam, but it breaks up into large blocks. The workings are reached through a tunnel (Fig. 169). The first few yards, in loose soil and rock, are bricked up; further in, timber supports are used, till the rock stands by itself.

This is a machine mine, the equipment consisting of two Sullivan long-wall machines, and two Goodman chain-breast machines, both driven by electricity. The Sullivan has the advantage of working continuously across the face when once

Fig. 167.—Boring a Shothole.

the sumping cut is in, whereas the Goodman is only fed forward, so has to be withdrawn for each cut. But there are certain constructional features about the Sullivan machine as put on the market which the manufacturers would do well tc remedy, instead of leaving it for the users to alter. The upper ball bearings of the armature shaft have had to be replaced by ordinary brass bearings, as the balls were found to cut grooves in the sleeve surrounding them; this caused the bearings to become heated. The heavy armature being arranged vertically, its weight has to be supported on the lower bearing, which is about two inches in diameter; consequently much

mechanical heat is added to that generated by the electricity. This lower bearing being out of sight, its lubrication is apt to be neglected. At Rhondda an automatic and more readily accessible lubricator has been attached. The two small studs that support the lower bearing practically trail on the ground, and tempt Providence to break them off by bumping against obstacles, when they snap off; then the bedplate has to be tapped for larger studs, and this is repeated till the limit is reached. The bedplate is cast metal of irregular thickness, and the strains set up in cooling tend to cause fractures. At Rhondda they have had new bedplates made of cast steel. One objection in working this machine is that when putting

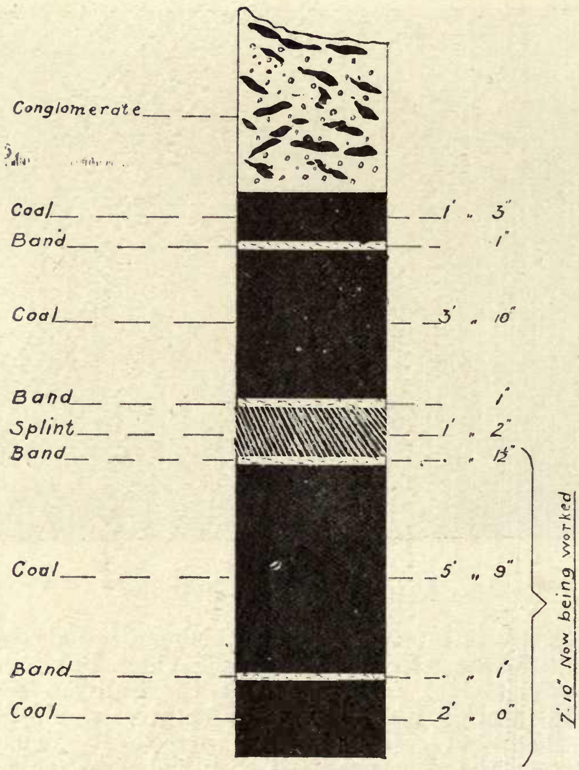

Fig. 168.—Section of Upper Seam, Rhondda Colliery.

in the sumping or opening cut, the cuttings are hemmed in by the sides of the pan, so that they cannot be shovelled out. This obliges the machine to plough its way in, and causes

great strain. The Goodman machine has its armature arranged horizontally, and in consequence does not heat like the Sullivan. Both the Goodman machines cut in 7ft. deep, but one only cuts 3ft. 9in. wide, while the other cuts 4ft.

The present electric installation consists of a dynamo built by the General Electric Company, which is compound wound, and has four poles. It generates 220amp. at 250 volts, and is belt driven from a horizontal Fleming engine. This plant will shortly be substituted by a high tension plant. The dynamo, which was built by Ernest Scott and Mountain, of Newcastle-on-Tyne will generate 75kw. at 2200 volts. Direct-driven motor transformers will be installed in the pit to reduce the voltage to 250, and there will be three branch cables for the three districts.

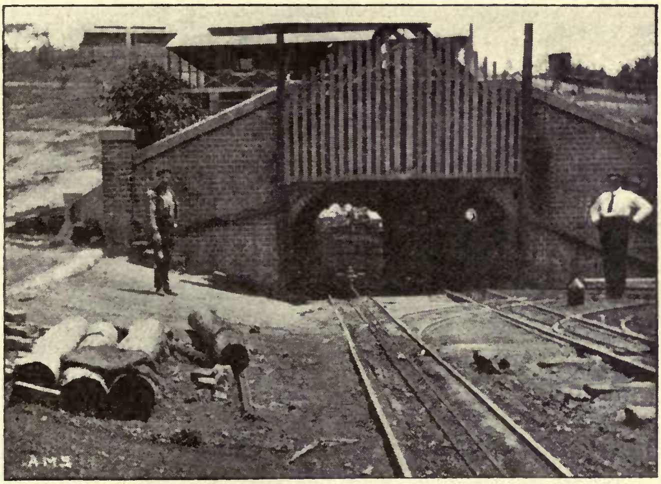

Fig. 169.—Mouth of Intake Heading, Rhondda.

The new high-tension cable about to be laid will be suspended from the roof. It is a three-core, lead-covered and armoured, suitable for a normal pressure of 2200 volts. The soft copper wire conductors are laid up in clover leaf pattern. Each core is insulated with the best Manila paper, and the interstices between the cores filled with spun jute, and the whole covered with Manila paper. The paper and jute are both thoroughly impregnated with resin oil. The cable is then covered with a continuous sheath of pure lead, on which is a layer of jute impregnated with preservative compound. This is protected by two layers of galvanised steel wire, laid in

opposite directions, the whole being covered with a layer of compound-impregnated jute.

The low tension cable is a single core, bitumen insulated, and single armoured cable; suitable for a normal pressure of 600 volts. The core is covered with a separator of paper, and over this is placed a cover of vulcanised bitumen. This is served with two layers of bituminised tapes laid on in opposite directions. The armour consists of a single layer of galvanised steel wires laid on in such a manner as to enclose the cable in a continuous ring of steel.

The trailing cables are 100yds. in length. The cable consists of two cores, each insulated with a layer of pure rubber, then two layers of vulcanised rubber covered with a layer of rubber-coated tape, and the whole vulcanised together. The two cores are laid together, and covered with a double layer of rawhide woven protection, which is more flexible than wire armour. Experiments are being carried out to make the rawhide distasteful to rats and mice. Where the trailing cables are clipped on to the low tension cable, the wires of the armour are cut and laid back over rings, which keep the wires in place. The cable is grounded at intervals along its course; but in case of a fault making the armour live, the cut armour is connected with 7-16th galvanised steel wire.

The haulage is done by an endless rope (Fig. 170), driven by one of Morrison and Bearby engines, with 18in. cylinders and 3ft. stroke, geared down to 1 in 13. At present the rope only goes in about 400 yds., but it will shortly be extended, the rest of the traction being done by horses. The skips are clipped to the rope from 2 to 4 in a set; and after being weighed on a Pooley machine, are run into a side tippler above a shaking screen. The skips then run down hill till they are picked up by a creeper chain, which carries them up to the main track again. The creeper chain is kept taut by means of a weighted pulley, which is suspended in a loop of it. The slack that passes through the screen falls on to a mechanical scraper, and is finally emptied into hopper waggons. The large coal falls on to a steel picking belt, with wrought-iron frame, so that boys can pick out pieces of band, the coal eventually being tipped into a shoot that guides it into waggons. Provision has been made for erecting another picking belt when it is required. The shaking screen, picking belt, scrapers and creeper chain are actuated by an engine built by Morrison and Bearby, having 12in. diameter cylinders and 18in. stroke. A throw-off switch is arranged on the outcoming line between the tippler and the mouth of the tunnel. It consists of a short length of rail, the lower end of which is fixed to the adjoining rail, while the other end is forced inwards by means of a weight at the end of a bell crank. The weight, how-

ever, is so slight that when a skip is proceeding towards the tippler the wheels force it to return to its proper position. Should a skip break away near the weighing machine and pass down hill, it would run off the rails at the point where the continuity of the line is broken.

The bords are made 8yds. wide, with 10yd. pillars, and are 50yds. long between cut throughs. A cut is then taken off for 2yds. deep on either side of the bords with the Sullivan machine, thus making the bord 12yds. wide, and the intervening pillars 6yds. There is very little water in the mine, and this is at present handled by a Knowles steam pump; but later on a pump shaft will be sunk in the deepest known part of the seam, and the pump will be removed.

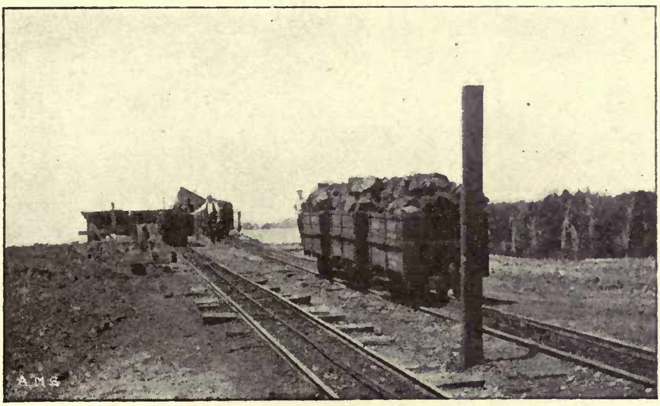

Fig. 170.—Skips proceeding to the Screens, Rhondda.

Ventilation is carried out by means of a furnace, which is cleaned out and banked up for the night. All the coal is removed right up to the roof of the furnace chamber, and air circulates on either side of the furnace, so that there is no fear of the coal in the seam catching alight. Although this is not a gassy mine, and naked lights are used, yet a man tests every working face with a safety lamp before the miners go to work, and makes marks to that effect to prove he has been there.

Steam is generated in three Cornish boilers and one Stirling boiler. The standard Stirling boiler consists of three upper or steam drums, and one lower or mud drum, which are connected together by three banks of tubes, and short circulating tubes

connect the three upper drums together (Fig. 171). All the tubes are bent slightly, so as to allow them to enter the drums normal to their periphery, and provide for expansion and contraction. The steam spaces of all the upper drums are connected, while the water spaces of only the front and middle drums communicate. All parts subject to pressure are of wrought metal, and either spherical or cylindrical in form, so as to mitigate the tendency to distortion under pressure. By suitably disposed fire-brick baffle walls, the gases from the grate are led up among the first bank of tubes, thence down the middle bank, up the rear bank, and on to the chimney, so they have every opportunity of giving up their heat to the water. The feed water enters the boiler at the coolest point;

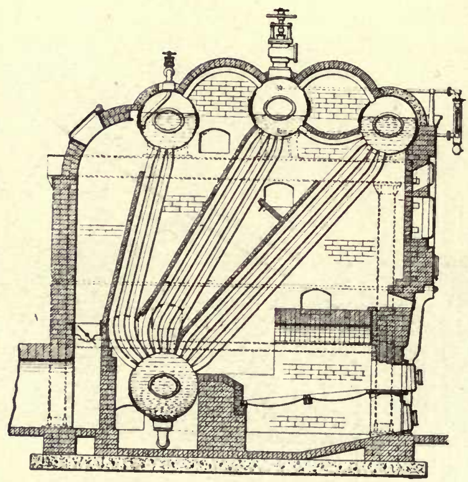

Fig. 171.—Sectional Arrangement of the Stirling Boiler, Side Elevation.

that is, at the rear steam drum. The lime salts in the water that are rendered insoluble by the heat. settle in the mud drum, and can be blown off as required. The mud drum is protected from the heat of the furnace by the bridge wall. Every tube has an outlet to the steam drum equal to its full area. The removal of one manhole door from the end of each drum renders every part of the interior accessible for cleaning. The tubes being only slightly inclined from the vertical, there is little opportunity for soot or dust to collect on the outside surfaces of the tubes, and as the tubes are arranged in parallel rows, they can be thoroughly cleaned on the outside by means of a steam hose. The bent tube performs the same function as the expansion loop or bend in a steam main, inasmuch as

each tube may expand or contract independently of the others without straining the boiler. The tubes are inclined at such an angle as to admit of easy and rapid liberation, and ascent of the steam generated in the tubes, and the circulation of water is such as to maintain a uniform temperature in all parts; thereby reducing strains and leaks due to unequal expansion and contraction. On account of the bend in the tubes it is not so easy to look through and ascertain whether they are clean as if they had been straight; also the boiler would be improved by having a larger water space in the upper drums.

Northumberland Colliery.

This colliery is owned by an English company, but is leased to Mr. F. R. Croft, and was managed by Mr. J. Rice for 12 years. The original company sunk two shafts about 20 years ago, one for about 500ft., the other for 250ft., in order to cut a 9ft. seam supposed to have been found

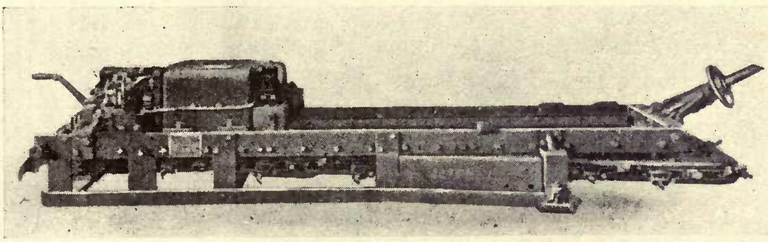

Fig. 172.—Jeffrey Electric Chain Breast Machine.

by a bore. But as they did not get the coal, they usd a diamond drill for a further 500ft., when they struck the borehole seam, which at this place was found to be about 3ft. thick. Besides these shafts a tunnel was driven into the side of the hill on the Great Northern seam; and this is the one now being worked. The seam is about 15ft. high, but only 7ft. to 7ft. 6in. of the coal is removed from the middle; the top and bottom coal being left for roof and floor respectively. The seam has a splendid roof of conglomerate.

There are two coal cutters at work in this colliery, one a Jeffrey, the other a Goodman. The Jeffrey (Fig. 172), makes a cut 6ft. deep and 3ft. 9in. wide, and is the lighter machine of the two. The starter is at the rear of the machine, and a hand wheel for revolving the chain when required to change picks is at the side. The trolley on which the machine is mounted when necessary to flit from one place to another is self-propelled by a chain from the machine, which passes round a

sprocket wheel on the trolley, that in turn is connected with, and drives, the rear pair of wheels. A reversing switch enables the trolley to move either backwards or forwards. The Goodman machine (Fig. 173) makes a cut 7ft. deep and 3ft. 9in. wide. It has side rollers at the end to assist in moving it parallel with the face of the coal being cut. There is a handle at the back for rotating the chain when desired to change the picks. Sockets for the picks form short links in the chain, and are at different angles, so as to give clearance. The pick points are held in the sockets by set screws.

A Tangye engine 10in. x 10in. is used to drive a Siemens Bros.' generator. This is a direct-acting dynamo of 19.5kw., 65.5 amp., and 260 volts. Besides providing electricity for the coal cutters, it also provides the necessary power for a three-throw electric pump.

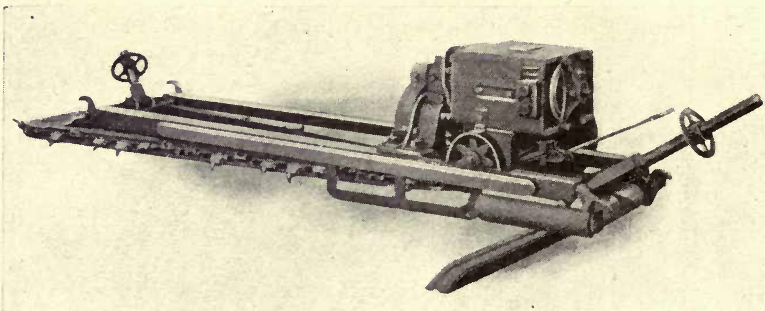

Fig. 173.—Goodman Electric Chain Breast Machine.

Ventilation is carried out with the help of a furnace. All the traction in the mine is done with horses, but the skips are conveyed from the tunnel mouth to the screens for the first section by gravity, and for the second by an endless rope. The slack of the rope is taken up by a pulley, the bearings of which slide up and down between vertical posts.

New Lambton Colliery.

The New Lambton and Ebbw Vale collieries are practically one and the same, and belong to the New Lambton Land and Coal Company of New South Wales. The New Lambton worked a lower seam from a shaft, now disused; while the Ebbw Vale works a top seam, 240 to 250ft. higher up, from a tunnel. The tunnel and shaft are close together, and the screens and weighing machines, which are located near the shaft, are used for the coal now brought out from the tunnel.

The skips are hauled out by an engine, sixteen to a set, and run back by gravity. The last skip coming out has a dragbar attached to the socket for the horse limber by a bolt and cotter. Two pumps are worked from the surface by means of endless ropes driven by geared engines similar to those used for endless rope haulage, a tension pulley being employed to keep the ropes taut. The coal is extracted by the usual bord and pillar system; the 8-yard bords being worked by one man in each.

Waratah Colliery.

This colliery belongs to the Caledonia Coal Company, who work the Victoria Tunnel seam from a shaft, on the pillar and bord system, the bords being eight yards wide, and the pillars 10 yards. They work 4ft. 6in. to 5ft. thick of coal, which is mined by pick, no machine coal cutters being used. The coal is conveyed out of the mine by the endless rope system of haulage. The drainage is done with an electrically driven centrifugal pump and steam pump of the Cameron type. The generator for driving the electric pump, and providing the lights, is one manufactured by Ernest Scott and Mountain, built for 250 volts, 28 amp., and is direct-driven.

A Schiele fan is used for ventilation purposes, which is belt-driven from a steam engine. These fans are encased in a volute air chamber, so that the passage along which the air travels after passing through the fan gradually increases in area until it finally escapes. The blades of the fan are wider towards the centre than at their tips, so as to compensate for the increased area at the periphery.

The coal trucks, both box and hopper shaped, are made of wood. Wood is easier to repair than iron or steel, and is not affected in the same way, by the salty atmosphere of the coast.

Purified Coal and Coke Company.

This company obtains its coal from the Wallsend colliery. The small coal is crushed in Cornish rolls, but if there is a shortage of small coal, so that round coal has to be used, this is given a preliminary reduction in a jaw breaker, and the product is then raised to the rolls by a bucket elevator. The coal that passes between the rolls is then elevated to four jigs. In these, since the coal is lighter than the slate, it passes over the tip in front, being assisted by a revolving paddle. The slate sinks to the bottom and is allowed to pass out of the jig by opening a valve periodically when the slate has collected in sufficient quantity, which can be ascertained by feeling with an iron tool. The valve cannot be left open all the time, as the same quantity of dirt does not accumulate constantly.

The washed coal passes to a Carr's disintegrator, to which it is raised by a scraper elevator, the bottom of the trough being made of perforated copper so that the coal drains as it travels along. From the coal hopper, which holds enough for a day's work, the crushed coal is fed into canisters that are drawn backwards and forwards over the ovens by an endless rope, which is capable of being reversed. The canisters have a special hook on one side at either end; a short chain is hooked on to the canister, and a clip at the other end of the chain is fastened to the rope. When the canister gets near the end of its trip the rope stops, but the

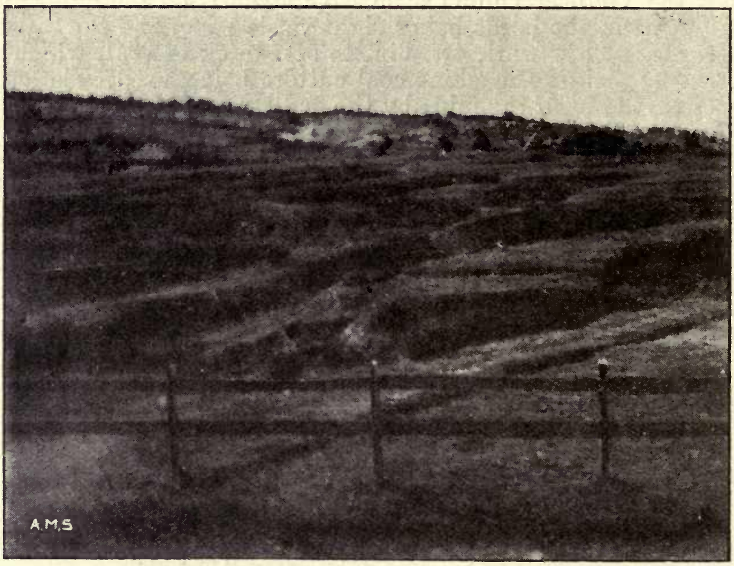

Fig. 174.—Irregularity of Surface, due to caving in of ground between Pillars.

inertia carries the canister further on, in consequence of which the chain becomes automatically unhooked. There are 70 ovens, mostly of the round beehive pattern, having a capacity of 7 tons each. The coal is reduced in weight to one-half when converted into coke.

Maryland Colliery.

This colliery, formerly owned by the Co-operative Company, is now in the hands of the Sneddon family, and is managed by Mr. D. Sneddon. The old workings of about 50

years ago had 8-yard bords, and 4-yard pillars. The latter not being strong enough, the roof has collapsed, and the surface in places looks like a gigantic ploughed field. Fig. 174 gives an idea of the appearance of the surface, at a place where there is about 30ft. of cover. The direction and position of the bords and pillars can be readily distinguished. The creek has broken into and flooded a portion of the old workings. Now both bords and pillars are made 6 yards wide. The following is a section of the seam:—

Roof, shale, does not stand well.				
Little tops (coal: this is left, as it makes a good roof)	1ft.			
Penny band		1in.		
Big tops (coal)	2ft.			second working.
Penny band		1in.		
Coal	2ft.		extracted. 8ft. coal	
Penny band		1in.		first working.
Coal	4ft.			
Floor hard sandstone.				

The lower 6ft. of coal only is taken out when mining the bords in the first instance; the upper 2ft. of coal is extracted in the bords at the same time that the pillars are drawn. When drawing the pillars, as the roof is tender, a strip of coal is taken out right across the pillar at the far end. The roof falls close up to the face in spite of the timber used to support it. When this happens a stump is left for three yards, and then a four-yard crosscut is put through the pillar, after which they start to take out the stump; if the roof does not fall again, they go ahead till it does, and then proceed as before.

The chief trouble in this mine is the water. Coffer dams are built of timber and clay to about 6in. above water level, so as to hold it back. The combined pumping capacity of all the pumps in the mine, which can be put into commission in case of emergency, is 150,000 gallons per hour.

The Co-operative Colliery.

This colliery, situated at Plattsburg, is owned by Messrs. Laidley and Co., and has been managed by Mr. Jas. Barr for the past 19 years. It is an old mine, and the miners are now chiefly engaged in extracting pillars. The pillars are worked in two lifts of 4 yards each. One lift is extracted in-bye the other out-bye.

The seam is from 5 to 6ft. thick, and a section of it is as follows:—

Coal, 1ft. 9in. to 1ft. 6in.
Band, 1in.
Splint coal, 3in.
Coal, 1ft 5½in. to 1ft. 3in.
Band, 1in.
Coal, 2ft. 5in. to 1ft. 8in.

The main pump is a Knowles' steam pump, located at the bottom of a 70ft. shaft, and is capable of raising 60,000 gallons per hour. There is also a 3in. electrically-driven pump, put in by Crompton and Co., which is interesting as being the first electric pump used in a New South Wales colliery.

There are five haulage engines, all working the main and tail rope system, with the exception of one endless rope

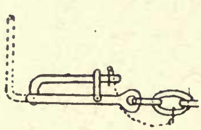

Fig. 175.—Goose neck hook.

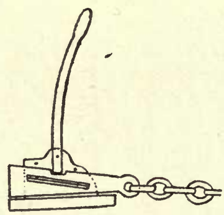

Fig. 176.—Clip.

system, which has two branch loops working two districts; this rope also formerly worked a pump. When on a main and tail rope track a down grade is met with, the skips are lowered by gravity on one rope, and hauled up a reverse grade by the other. Formerly there were 14 miles of wire rope circulating through the mine. On the surface the haulage from the tunnels to the railway line is 1½ miles, done in two sections. A goose-neck or knock-off hook (Fig. 175) is used at the hauling end of a train of skips to connect the skips to the rope. The clip used for connecting a set of skips to the endless rope, when fetching them up to the main and tail rope system, is shown in Fig. 176. This colliery has 67 beehive coke ovens, but they do not find it necessary to wash the coal, as is done at Wallsend.

Duckenfield Collieries.

There are two collieries situated at Minmi belonging to Messrs. J. and W. Brown. One is known as the Duckenfield or old tunnel; the other as Back Creek or new tunnel. The newness, however, is only relative, for both collieries are fairly old, and their workings are connected. Some of the coal is

won from bords, but most is obtained now-a-days from the pillars. These collieries are under the management of Mr. George Durie.

The seam worked is the Bore-hole, which is from 3ft. 9in. to 4ft. 6in. thick. On account of being so low, the roof has to be brushed to make headroom. It is worked on the bord and pillar system; the bords being 8 yards and the pillars six or eight yards wide. The method of extracting the pillars depends principally on the nature of the roof. Cut-throughs are made about 40 yards apart. If the roof is of fairly good shale or sandstone, each alternate cut-through is put in order, and a roadway made on the out-bye side of the pillar to be extracted; the roof of the bord is supported with props, and any loose rock in the way thrown on one side. A pair of men then take out a cut four yards wide off the far

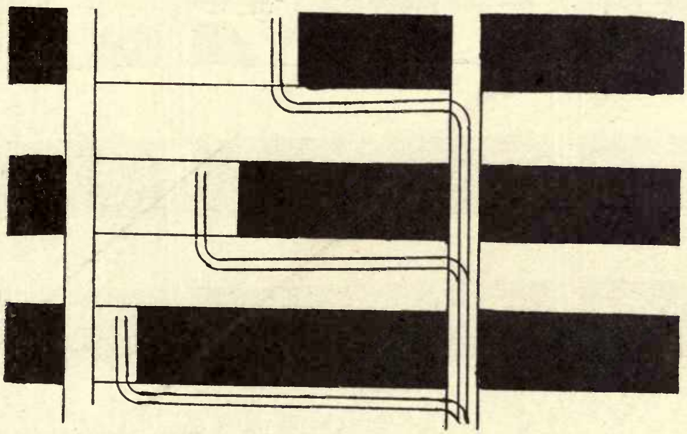

Fig. 177.—Pillar Extraction, with fairly good roof.

end of the pillar, and rails are laid for the skips to run on. The men then continue to work the face of the pillar as if it was a bord, bringing the rails up to a convenient distance as the work proceeds (Fig. 177).

Where the roof is bad and the bords fallen in, all the cut-throughs have to be cleaned out and repaired. The pillar is then worked forward from each side of the cut-throughs. At first only four yards wide is worked, leaving a stump of coal four yards in width, but the cut is gradually increased till it is the full width of the pillar (Fig. 178). The object is to extract half the length of the pillar between cut-throughs from each starting point, but circumstances seldom permit of this being accomplished. When a cut-through has fallen in, the roof, at its sides, has to be supported on chocks. When starting to extract the pillar of a district a commencement is

made with those furthest in-bye. These pillars are in different stages of attack at the same time from one cut-through; that furthest in-bye being of course most advanced.

The ventilation is carried out by means of three Schiele fans, 5ft., 10ft. and 12ft. in diameter, respectively, and one furnace.

The disposal of the water in the mine is as complicated as the arrangement of the ventilation. This is on account of the extensive workings, and various hollows, and the necessity of not drowning out any particular pump, thus putting it out of commission just when it is most wanted. By means of a system of dams provided with gate valves, the flow of water can be directed to different places; and if too much for the pumps, it is diverted for the time being to old dip workings,

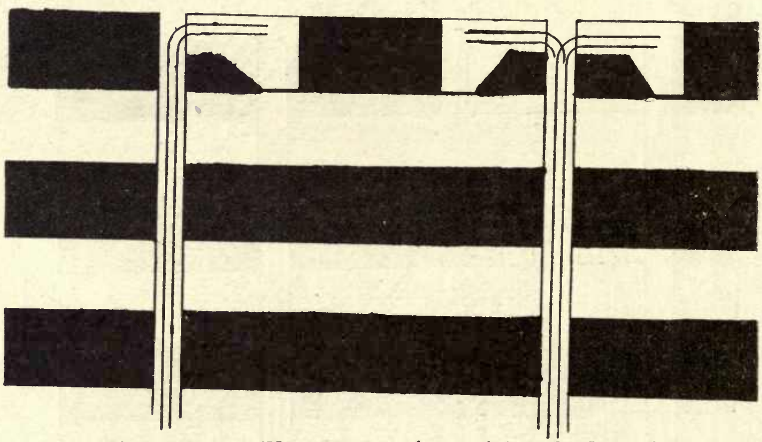

Fig. 178.—Pillar Extraction with a bad roof.

where it can do no harm. The dams are built up of brick laid in cement, are 14in. to 24in. thick, and are let about 4ft. into the walls. Of course a suitable locality is selected, both with regard to the workings and the soundness of the rock. Some dams are only about 5ft. high, and any excess of water flows over the top. Others completely stop the heading in which they are placed, being built right up to the roof. The dam is given a convex curve towards the impounded water, but as there is no head to speak of, there is no necessity to make the dams specially strong. The gate valves in connection with the dams are 6in. in diameter.

There are several Tangye pumps. Some are driven by steam, one by oil, one by rope, and one by horse-power. The latter, which has three 4in. rams, pumps water for a distance of fully a mile against a head of 140ft. The rope driven pump

is double acting, and the rope passes into the mine for half a mile. The oil pump is a three-throw.

At present the mechanical haulage all over the two collieries is done by engine planes, the skips entering the mine by gravity. One engine plane is 2300ft. long, another a mile, while a third is a mile and a quarter; there are 28 skips to a set. A main and tail rope is about to be installed at No. 2 tunnel. The direct haulage is fed by self-acting inclines and horses down below.

On the bank there are the usual weighing machines, kick ups, shaking screens, and picking belt, also a slack storage hopper. Between the two collieries is situated the workshops, where local repairs are made; but the Brown's main shops are located at Hexham. Here they employ over a hundred men at the saw-mill, pattern-makers' shop, foundry, etc., making waggons, repairing tug boats and locomotives. They find wooden waggons last longer than those constructed of iron or steel, as the latter rust with the sea air, and in case of a smash a plank or two are easier to replace in a wooden waggon than to mend one made of iron or steel.

This is really a naked light colliery, but safety lamps are now used when extracting the pillars, except in some of the shallow workings. Monobel is the explosive used to break down the coal, it being fired by means of a Nobel's low-tension battery. No coal machines are used in these collieries, all the holing being done by hand. There are 24 boilers, Lancashire and Cornish, under steam at Minmi.

Seaham No. 1 Colliery.

This colliery is about 20 years old, and works the Borehole seam from shafts. The downcast shaft, 460ft. deep, up which the coal is hoisted, is 16ft. in diameter; while the air shaft is 13ft. in diameter. Near Blue Gum Creek there is another downcast, known as the Blue Gum shaft. At the latter shaft there is a Norwalk air compressor. This supplies the motive power for working three pumps, all of the Worthington type, also the Hardy punching machine. Only one of the Hardy machines is used, and it cuts two 4-yard places for a depth of 5ft to 6ft.; 15 square yards being considered a fair day's work, without allowing for breakages. It is only rigged up once for a 4-yard bord cut, when it is placed opposite the middle of the face. The Little Hardy is found to be too light for the work it is called on to do, consequently breakages are frequent. The air hose is served with marline, which is given a half hitch every turn, so as to prevent it from coming undone in case it is severed.

Horses draw the coal from the working places, a limber being used to hook the horse on to a skip. The limber throws

all the weight on the horses hips, and as the frame is stiff it sticks out straight behind, and does not knock against the horses legs like a chain might. The horses are stabled below ground. The main and tail system of haulage is used to the shaft, the present main haulage being $1\frac{1}{4}$ miles in, after which it is fed by an auxiliary haulage. The main rope is $2\frac{1}{4}$in. in circumference, and the tail rope 2in. The main and tail rope engine, made by Messrs. R. and J. Morison and Bearby, consists of a pair of 16in. diam. cylinders with 2ft. 6in. stroke. A clutch fixes one or other of the drums, while the other runs loose. Signals are given to the engine driven by means of elec-

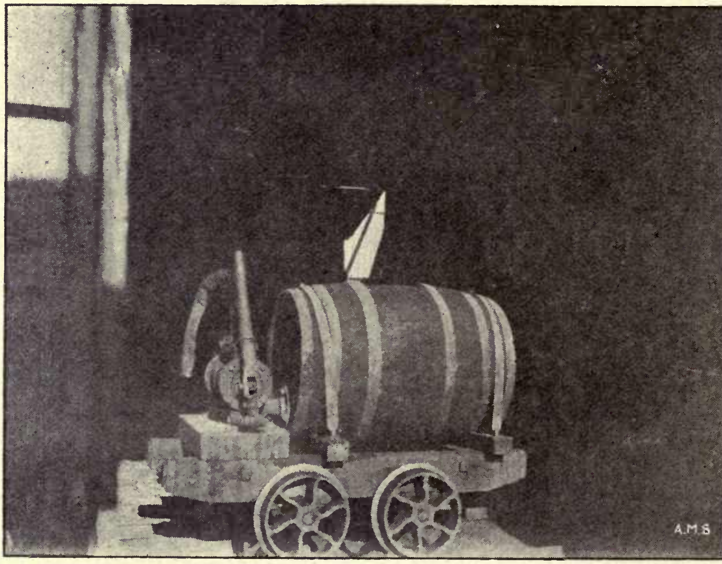

Fig. 179.—Water barrel and pump.

tric bells. Safety lamps are used at this colliery, and when the men are at work an iron rod about 5ft. high, stepped into a wooden support, is used to hang the lamps on—two crooks being arranged at the top, and one near the bottom.

Water pipes, with stand pipes about every 40 yards, are laid along the main roadways. In pillar work, since a good deal of dust accumulates in the bords, the shot-firer sprays the neighbourhood before firing. Monobel is the explosive used. The apparatus used consists of a barrel placed on its side on a trolley, to which it is strapped (Fig. 179). Water is forced out of it by a hand pump mounted on the end of the trolley, and to which a short length of hose is attached with a

nozzle at the other end. Where bailing has to be done in dip workings, the water is conveyed away in a similarly-arranged barrel. The air is circulated by a 30ft. diam. Waddle fan, which is given 60-63 revolutions per minute.

The pit-head frame is constructed of steel. The steam hoist made by Grant, Ritchie and Co., of Kilmarnock, is direct acting, has slide valves, 26in. diam. cylinders and 5ft. stroke. The drum is conical, having 12ft. and 19ft. diameters, and a splash board at the back prevents the rope dressing from being scattered about the engine room.

Shaking screens are used for screening the coal, but when "shandygaff" is required, a sheet of iron is bolted on to the

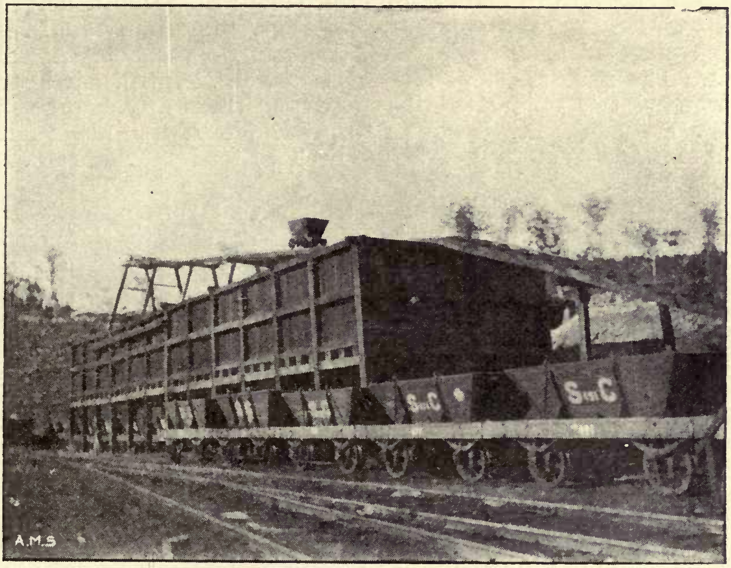

Fig. 180.—Coal Boxes.

bars of the screen. If on passing over the picking belt, it is suspected that more than 20lb. of dirt to a skip are picked out, it is put on one side and weighed, and if found to be in excess of the amount allowed, the man responsible for the skip is suspended, unless he can give a reasonable explanation. The slack not required for immediate shipment is conveyed up an incline in a hopper-skip to rectangular wooden coal boxes (Fig. 180).

The boilers are of the Cornish type, 28ft. long by 5ft. 6in. in diameter. The feed-water is heated by exhaust steam, and

fed to the boilers by hot-water feed pumps. The fitting-shop contains the usual lathe, drill, shears, etc.

Seaham No. 2 Colliery.

This colliery belongs to the same company as Seaham No. 1, and works the same seam. It was laid out by the superintendent, Mr. Fairley, and has been arranged for an output of 1200 tons per eight hours.

The main shaft is 650ft. to the bottom of the sump, which is 10ft. deep. It is 16ft. in diameter, while the up-cast shaft is 14ft. in diameter. The pit-head frame is 70ft. high to the centre of the 14ft. pulleys, and is made of wood. The guides for the cages to run on are of 70lb. steel rails in 38ft. lengths, fastened to buntons every 9ft. by dogs. The individual rails are connected by fish-plates, there being eight holes in each rail. The rails are kept true by a dowel let into their heads. There are two guides to each cage, and these are arranged on the same side of it. In order to prevent overwinding, a King and Humble's safety hook is used. Two tons of coal are raised every hoist.

At the air shaft there is a trolley that runs on rails over the mouth of the pit. This is to receive the skip that is hoisted up while sinking is going on. During this period a rider, running on two guide ropes, prevents the skip from swinging about unduly in the shaft. Eventually a cage will be installed. Since the rope guides have to be paid out periodically as the shaft is deepened, the rope is coiled up on a wooden reel on the ground, and one end passes over a pulley and down the shaft. The rope is lowered as required by a hand brake. So that the strain due to the weight of the rope shall not come on the reel, a clamp is made fast to the rope at the surface, and to this a double sheave block is hooked; a single sheave block is then fastened to some stable object, and a chain reeved through both of them.

The sinking engines are both of the same type, made by Messrs. R. and J. Morison and Bearby, of Newcastle, N.S.W., being duplex, geared, and with a single drum. One has 12in. diam. cylinders, with a $2\frac{1}{2}$ft. stroke; the other has 14in. cylinders. The winding engine, manufactured by Grant and Ritchie, of Kilmarnock, has 28in. diameter cylinders and a 5ft. stroke. The drums are conical, with end diameters of 12 and 14ft. The foundation for the engine is made of iron tanks filled with concrete, one for each engine, leaving a clear space between for the drums and gearing.

The seam is 5ft 6in. to 5ft. 9in. thick, and is worked on the pillar and bord system. The pillars are 12 yards and the bords 8 yards wide. The top coal being inferior, the holing

takes place in that instead of in the bottom. A Little Hardy coal cutter worked by compressed air is used for the headings and narrow places; for the rest, pick work is used.

Compressed air is used, not only for the coal punchers, but also for the pumps. A Norwalk straight line compound air compressor is the type employed, driven by a single 20in. diam. steam cylinder, the air cylinders being 17½ and 24in. diameter (Fig. 181). The steam and air cylinders being in the same straight line, there are none of the cross-strains that duplex compressors are subject to. The air is compressed to 90lb. per square inch, and the capacity of the machine is 1650 cubic feet per air per minute. The air valves have a positive movement, and are of the Corliss pattern. The speed at which the air compressor works is determined by the consumption of the air, a uniform pressure being maintained in

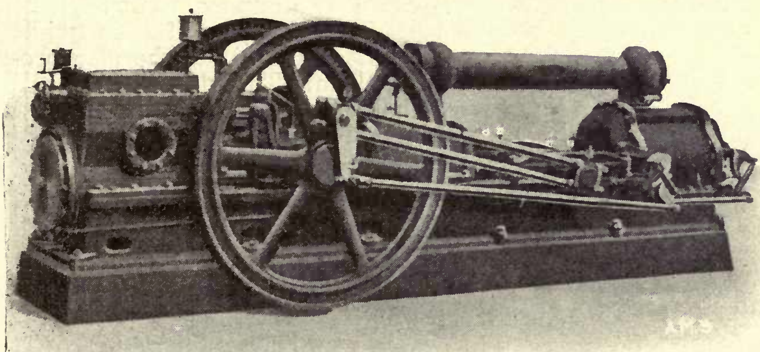

Fig. 181.—Norwalk compound straight line compressor.

the air receiver. This is done by means of an automatic regulator, which shuts off or admits steam according to the pressure of the air. The air pipes are spiral riveted, 6in. in diameter, made by Messrs. Mephan, Ferguson, of Footscray, Vic. There are two small air receivers below, one on either side of the shaft.

The main pump, located at the bottom of the down-cast shaft, is one of Evans' direct acting ram pumps, designed to raise 10,000 gallons per hour. The cylinders are 20in. diameter, the stoke 24in., and the rams, which are arranged horizontally, are 7in. diameter.

A Waddle fan, 35ft. in diameter, induces the necessary air current. It has ten long vanes and ten shorter ones, all of which are curved. This class of fan is peculiarly free from

vibration, owing to the air being discharged equally all round the periphery. A register made by Shaeffer and Budenberg Ltd. for indicating the number of revolutions made by the fan is connected with it.

The pit horses are brought to the surface every day, where they are provided with good stabling accommodation.

A Westinghouse generator of 185 E.M.F. and 46 amperes, driven by a Junior automatic engine, provide the electric lights.

The boiler plant consists of three Lancashire boilers 8ft. by 30ft., and two Cornish boilers 6ft. by 26ft. The mine water being bad for boiler purposes, water is pumped from a dam near the mine by means of a Stilwell-Bierce and Smith-Vaile Co.'s pump to an open feed water heater. The feed pump is one of Gardner's duplex double ram pumps. The shaking screens are 15ft. long, and are given 70 to 80 strokes per minute, the motion being imparted by a duplex engine.

There are two picking belts, 80ft. long by 4ft. 6in. wide, made by Messrs. Poole and Steel, of Balmain, who also provided the machinery for driving them. The plates of the belt are connected to three steel chains made of long links; there is one chain at either side of the belt, and one in the middle.

West Wallsend Colliery.

This is one of the Caledonian Coal Company's collieries, and is under the management of Mr. A. E. Warburton.

The down-east shaft is 482ft. deep and 16½ft. in diameter. Each cage runs on three wire rope guides, and are separated by two buffer ropes. The winding engine was made by Grant and Ritchie, of Kilmarnock, and has cylindro-conical drums, but only the conical portion is used, as the shaft is not deep enough for the rope to wind on to the cylindrical part. The drum is lagged with wood, but as the rope has worn grooves into it, it is now practically a scroll drum. The boiler plant consists of six tubular boilers, in which the tubes act as flues. Skips full of slack are drawn to the boilers from the pit's mouth by means of a rope, and the ashes are removed in a similar manner up a short incline, so that they can be emptied into a hopper waggon.

No coal cutting machines are used in this mine, all the coal being worked by picks.

A band rope passes down the air shaft, which works three endless rope systems underground, the different systems being put in and out of action by friction clutches.

The main pump is one made by Grant and Ritchie, and has a single steam cylinder, but a double ram. The water column passes up the air shaft.

The electric plant consists of a small dynamo by Thomas Parker Ltd., 30amp. and 105 volts, belt driven at the rate of 1220 revolutions per minute by a Tangye engine. It is used for the electric lights during the day, and for a small pump during the night.

A Guibal ventilating fan 30ft. in diameter and 10ft. wide, provided with a Walker's shutter, is used, and is worked with a $1\frac{1}{2}$in. water gauge.

The pit-head frame and pit-top is a steel structure. The full skips are weighed on a Pooley's water balance weighing machine, and run down grade to side revolving tipplers. A creeper chain raises the empties to the proper level for caging

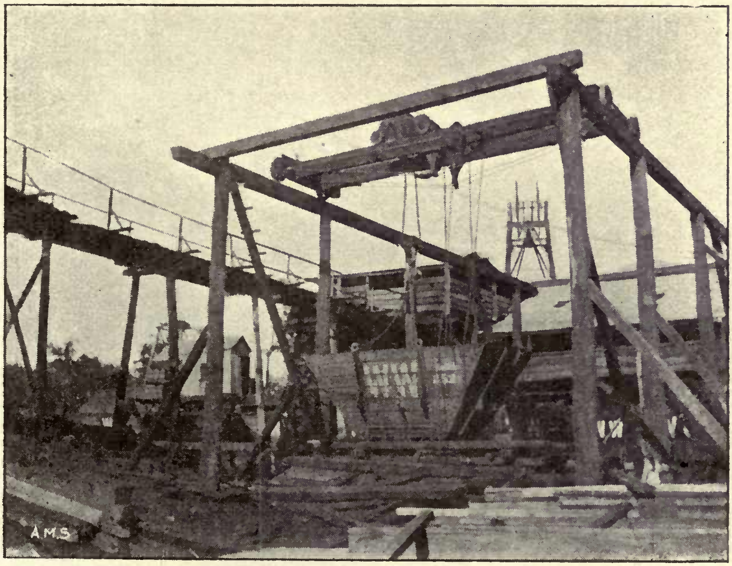

Fig. 182.—Travelling crane.

again. There are two picking belts. The slack, after passing through the screens, is raised by means of scrapers to a small hopper, from which it is filled into the hopper skip. There is no occasion to hinge the rails up which the hopper skip passes to the slack box, as is usually done, for they do not get in the way of the railway waggons, which are made to pass round a curve.

On the Thursday night of pay-week, each man is given a pay slip with his number, name, and amount owing written on it, which he brings already signed on the following day,

and gives in exchange for his money. The pay for each man is counted out beforehand and placed in a tin cup kept on a rack properly numbered. In this way there is no delay when paying a number of men.

The company's waggons are repaired on the premises. Fig. 182 shows the overhead travelling crane used for lifting the body of the waggon off its under-carriage.

West Wallsend-Killingworth Colliery.

This colliery belongs to the Caledonian Coal Company, and adjoins the West Wallsend colliery, owned by the same company. It is reached by a private line from Cockle Creek. Most

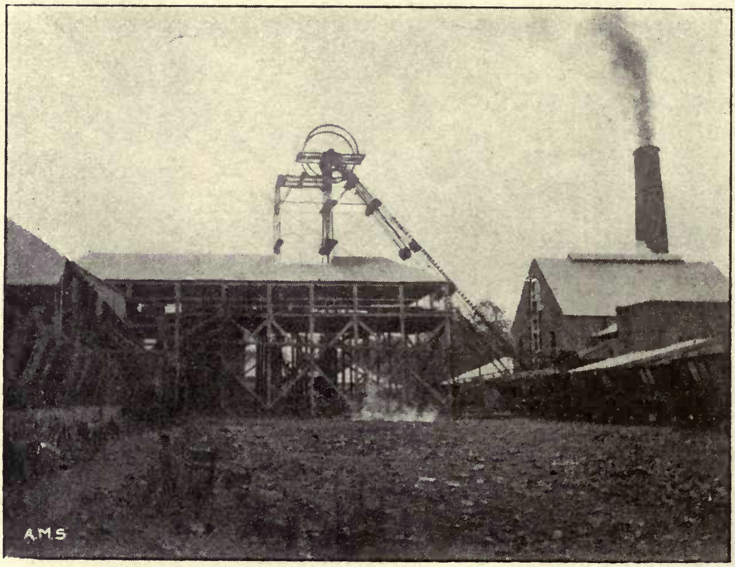

Fig. 183.—Headframe and heapstead.

of the miners reside in the township of Killingworth that has sprung up on the property. The mine is under the management of Mr. A. E. Kirk. Here, as at the neighbouring collieries, the Borehole seam is being worked, but the Young Wallsend seam has also been touched. This colliery, working under similar conditions to the West Wallsend colliery, and belonging to the same company, in most cases uses similar machinery and methods. The dip of the seam being slight, they are able to open out the bords, both to the rise and to the dip.

The shafts are 620ft. deep, the downcast being 16ft. in diameter, while the upcast or air shaft is 15ft. in diameter. The downcast shaft is surmounted by a steel head-frame, and adjoining it is a wooden heapstead (Fig. 183). The hoisting engine is one of Grant and Ritchie's, with 29in. cylinders; the drum is cylindro-conical, having 12ft. and 14ft. diameters. The cage is suspended from the rope by six chains, one in each corner, and two in the middle. Those in the middle hang slightly loose, so as not to take any of the weight, being only required in case of emergency should the others break. Chairs are pushed forward under the cage by the banksman on the arrival of a cage at the surface, but the chairs are pushed back again out of the way by the off-going skips striking a trigger: so as soon as the on-coming skips have pushed the others off the cage, and taken their places, everything is in readiness for the engine-driver to lower away.

The haulage underground, as in the case of the West Wallsend, consists of three endless rope systems worked by a strap rope from the surface and thrown in and out of gear by clutches as required. Ventilation is carried out with the help of a 35ft. diameter Guibal fan.

The number on a miner's token varies with the place where he is working, but the number of his lamp is always the same, and a token is hung up on a peg when his lamp is taken below. In this way the management can ascertain how many and what men are at work, and where they are employed.

The side tipplers are put in motion by a wheel, which is always revolving, but which is only brought in contact with the rim of the tippler by means of a lever when desired to turn it. A creeper chain is employed to return the empties to the other side of the shaft for re-caging.

There are two shaking screens with slots for the slack to pass through. Water plays on them in order to lay the dust. There are also two picking belts, one for each screen. The slack is taken by a scraper elevator to a certain point, from which another similar conveyor takes what is required to the boilers, while a third takes the bulk of the slack to hopper waggons. The scraper-chains are worked by sprocket wheels.

The waggon rails below the picking belts are given a grade of 1 in 80, so that they can be readily started. Instead of having a travelling crane for removing the body of a waggon from its under-carriage, as is commonly the case, a derrick is used. The repairing shop contains two lathes, a screwing machine, shears, steam hammer, punching machine, two drilling machines, and two planing machines. The boiler plant consists of six Cornish boilers, built by Hudson Bros., of Clyde, N.S.W.

The General Electric Company have supplied a continuous current generator of 240 amp. and 250 volts, driven by a compound engine, and intended for haulage, but at present it is used for lighting purposes and for driving a centrifugal pump.

Newcastle A. and B. Pits.

This colliery belongs to The Newcastle Coal Mining Company Limited. Mr. J. Croft was manager for 19 years, but has been succeeded by Mr. H. J. Thomas.

The seam is from 3 to 10ft. thick. This is one of the only two mines in the Newcastle district, where the longwall method is worked; but the pillar and bord method is also used where the seam is thicker than, say, 5ft. In the longwall workings, the roof settles gradually without cracking or bumping. It settles down as a whole, first bending about 20ft. from the

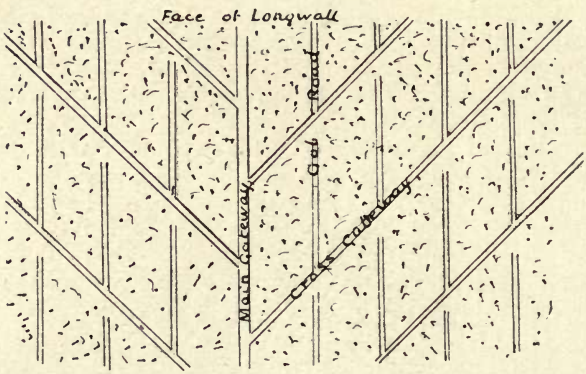

Fig. 184.—Long Wall System.

face, and finally settling about 50ft. from it. There are two longwalls, one about 250yds., the other about 300yds., the lengths being limited by local conditions. The main gateway is at right angles to the straght longwall face (Fig. 184); cross gateways branch off from either side of the main gateway at an angle of 45deg. towards the face, those on the same side being 50yds. apart, but they junction with the main gateway alternately with those on the other side. Branching off from the cross gateways on the coal side, and running parallel with the main gateway, are gob roads placed 30yds. apart, which help to shorten the distance the coal has to travel to the shaft. Packwalls are built on either side of the gateways, and are made 4ft. thick; chocks are built in every 4yds. These get squeezed together as they take up the weight of the roof, so that a roof originally 5ft. 6in. high

comes down to within 2ft. of the floor. The coal cutting is done by means of a Sullivan machine, which requires 30h.p. to drive it. It makes a cut 6ft. deep and 4in. high, and is flitted along the gateways on a self-propelling trolley.

Coal is shot down in some of the pillar workings, with bobinite, and in the bord workings with ordinary blasting powder. Naked lights are used below except in some of the pillar workings, where safety lamps are employed. The open lamps burn tallow, which the miners themselves provide.

When testing the depth of cover in those workings under the ocean, boreholes have to be put up, and for that purpose a serrated bit of $\frac{1}{4}$in. steel is used, having 8 teeth, set alternately in and out, so as to give a clearance of $\frac{3}{4}$in. The vertical portion of the teeth is $\frac{1}{2}$in., while the bevel is 1in. This crown cuts out a core 1in. in diameter. The core barrel is made in two lengths, 2ft. 6in. and 5ft. At the end of the

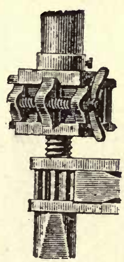

Fig. 185.—Stayner's A Nut.

core barrel, an ordinary solid rod of square cross section is screwed in; these rods are made in 2ft. 6in. lengths. The rod is rotated by a ratchet worked by hand. Stayner's patent nut (Fig. 185), is used with this appliance, which does away with the necessity of unscrewing the feed screw, since the nut can be caused to slide back when desired to add a fresh length of rod. The bottom of the ratchet is fitted into a small hole in an iron plate placed on the ground, so as to give it sufficient support.

The main and tail rope system of haulage is used in the main roadways, a set of 45 skips travelling at the rate of 14 miles per hour. Skips are gathered to the flats by ponies and horses, varying from 12 to 15 hands high, according to the place they have to work in. When a train of skips has been pulled up on the kip, a knock off bar (Fig. 186), fixed across the line, hits the devil, or detatcher, which is a bell crank attached to the end of the leading skip, and draws out the pin of the shackle that connects the end of the rope with

the front skip. An inverted V-shaped plank between the rails throws the chain clear of the line, so there is no fear of a loaded skip being derailed.

The shaft, which is 300ft. deep, is fitted with the usual cage for holding two skips end on. The cage runs on steel rail guides, which engage shoes attached to the ends of the cage, except when at the top and bottom of the pit where end guides would be in the way of those running the skips on and off the cages. The shoes being situated at the ends instead of at the centre of the sides, keep the cage steadier when in motion. The hoist is a duplex, horizontal, direct-acting engine, with slide valves, and cylinders that are 26in. diameter, and a 4ft. 6n. stroke. The levers for manipulating this engine are arranged at one side, instead of between the cylinders, as is usual. The dial indicator is worked from the connecting rod at the point where it is pinned on to the disc.

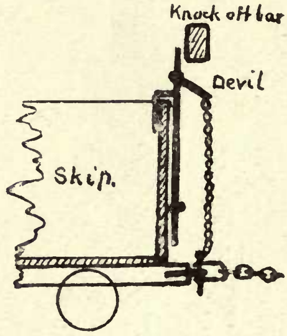

Fig. 186.—Skip Detacher.

At the surface the skips are run into an end tippler, and emptied on to a screen, which has a door across it to regulate the quantity of coal that slides down. The slack falls into a tray, which is weighed on an Avery machine. The round coal falls into another tray, which is weighed on a similar machine. Boys and men break up the lumps that show band or brasses, and throw the dirt on one side before the coal is emptied into waggons for the market. When not filled direct into waggons, the slack is stored in wooden coal boxes. There is a small hopper below the slack tray, which has double the capacity of the hopper skip. The reason why this is made to hold double the quantity is to allow room for the slack to accumulate in case there is a delay, such as when the hopper skip is engaged at another screen. The hopper skip

(Fig. 187) has a sliding bottom, with a hooked bar attached to it, that strikes an iron finger, which can be fixed to sleepers over any part of the box required. The automatic device consists of a piece of iron, bevelled on the up hill side, and straight on the lower; this gradually pushes the door open, and finally passes under it, as the door is not parallel with the rails. On returning, the door passes over the projection without touching it, and a boy pushes the door back before filling the hopper skip again. The hopper skip is drawn up an incline, over the coal boxes, by means of a rope wound up by a special engine. As the lower portion of the incline would be in the way of the waggons going under the screens if it was left permanently down, it is made to draw up on a hinge when not in use.

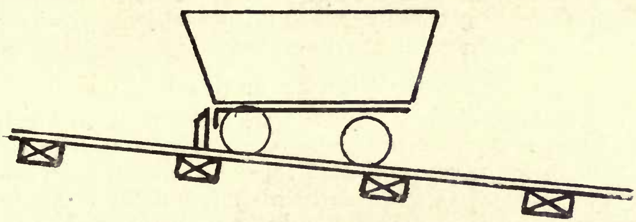

Fig. 187.—Hopper Skip.

The air current is induced by a Waddle fan 21ft. in diameter, which makes 80 revolutions per minute, when the mine is working, but the speed of the fan is reduced to 60 revolutions per minute otherwise. Though comparatively small, this fan has a greater capacity than a larger one of the older type, for it is fitted with a trumpet-shaped rim, and the blades are bent back so as to throw out the air, instead of being turned the other way, which scooped some of the air back again.

The colliery is unwatered by means of two electrically-driven pumps and two steam pumps.

The generator was provided by the General Electric Co., and is built for 90 amp. and 560 volts. It is driven by an Ames Iron Works engine. The cables underground are tied to bobbin insulators, with marlin. In case of a fall of roof, the marlin will give way first, and may thus save the cable. At the entrance to a gateway the cable is bared, so that the trailing cable can be clipped on. When not in use, the bared portion is protected by a wooden block clamped over it.

The steam plant consists of a Babcock and Wilcox boiler, which generates high pressure steam (120lb.) for the electric plant; there are also two Lancashire boilers and a nest of

egg-end boilers. The exhaust steam is led into an old boiler, through which the feed water is circulated; any grease is then filtered off through coke and bagging. A Weir hot water pump is used for feeding the boiler.

Electric signals are in use throughout the mine, and are connected with the hauling engine house at the surface. Communication by telephone may also be held between those at the surface and pit bottom, and persons employed in the different districts underground. An electric lighting plant supplies lights for the offices, workshops, engine houses, and also for the pit bottom. In the electrical workshop, the armatures are re-wound, and other repairs effected to the coal-cutting machines.

The workshops, where repairs to the machinery and rolling stock of the colliery are carried out, contain steel turning lathes, wood turning lathes, shaping and drilling machines, and a large steam hammer.

The New Winning or Sea Pit.

The "Colonial" Government was the first to work coal in the Newcastle district, where it operated the "dirty seam," the output averaged 3327 tons per annum between 1826 and 1828. This was eventually abandoned, and the Australian Agricultural Co., commonly known as the A.A. Co., was given a grant of 2000 acres on 2nd May, 1833, but previous to this, permission had been given the company to bore for coal. Mr. Henderson was the company's first colliery manager, and he began to search for coal on 20th September, 1831. From 1832 to 1840, the company produced 123,000 tons of coal. The retail business which the company had been carrying out was given up on 1st January, 1846, as it barely paid. At first, the "dirty" and "yard" seams were worked, but in 1848, a 10ft. seam of coal was found, at a depth of 145ft., now known as the "bore hole" seam, and at the present day this is the only seam worked. The following is a typical section of the borehole seam:—

	ft.	in.	
Top band of coal	4	0	III.
Band	0	1	
Top lift coal	3	2	
Band	0	1	
Bottom lift coal	1	9	
Morgan	0	6	I
Four-inch coal	1	0	
Band	0	1	
Little tops	1	0	
Jerry	1	3	II.
Bottom coal	3	1	

The inch bands are known as "penny bands." The morgan and jerry are carbonaceous shales. The roadways and bords are driven in the middle coal, marked I., which is first taken out. The second work consists of taking up the jerry, and putting that on one side, then the bottom coal is lifted. Finally, the top coal, which stands better than the rock roof, is taken down. The morgan and jerry are left in the bords, and the men stand on this so as to reach the top coal, but if there is not sufficient to enable the men to get near enough to their work, they stand on old grease barrels, which are easily rolled about from one place to another. They also use short ladders to stand on sometimes, but these are more easily damaged than the barrels. When removing the pillars, the bottom coal is left unworked.

In 1850, the A.A. Co. commenced shipping coal to South America. The miners went on strike in 1861, and having been successful struck again in 1862, but on this occasion their places were filled by men brought from Melbourne.

Several shafts have been worked by this company. At present the Sea Pit, which was sunk in 1888, is the main one. Mr. R. Thomas has been manager of it for the past seven years.

The headings are driven parallel with the facings, and are placed 70 yards apart. The different headings are known by the names of the men who started them. The bords are turned off at right angles to the facings, and are made 6 yards wide; the length or bord course is 33 yards, as cut throughs parallel to the headings are driven half-way between neighbouring headings so as to shorten the distance necessary to convey the coal to the main roadways. The cut-throughs are driven after the bords, as that gives a slight advantage in their cost, since that portion in the bord has been made in wide instead of narrow work, the latter having to be paid for at yardage rates. The pillars between the bords are 12 yards wide. The miners get paid at a higher rate for the middle coal than for either the top or bottom coal. The top coal is paid for at 3 pence per ton less than the middle coal, as it is already undercut, and only has to be dropped. The bottom coal is paid 2 pence per ton less than the middle coal, because in this case there is no holing to be done, but as there is more dirt to be removed than when dropping the top coal, the bottom coal fetches 1 penny a ton more. Sometimes small faults, say, 3ft. throw, occur in the coal, but as the seam is about 16ft. thick, the coal is not lost, and therefore does not require to be sought. Where the throw is over 3in., the miners are allowed 1½ penny for each inch of throw. The miners are paid less for pillar coal than bord coal, nevertheless the proprietors make less profit out of the former, on account of the timber that is lost

in the process of extraction. In pillar work only the coal above the morgan is won. On account of the height of the seam, the support for the drill used when boring shot holes has an extension rod, but when this support cannot be used, a hole is jumped in the face of the coal, and a square bar driven in, which serves as a bracket to which the nut, the feed screw of the drill works in, is attached.

The work at present being carried on is mostly pillar drawing. When a district has been prepared by doing the first working in the middle coal, the miners proceed to take down the upper coal in the bords and roadways, except opposite the stooks left temporarily for support. The pillar between two roadways is then divided in half cross-ways by an imaginery line, but the pillar is attacked from both roadways,

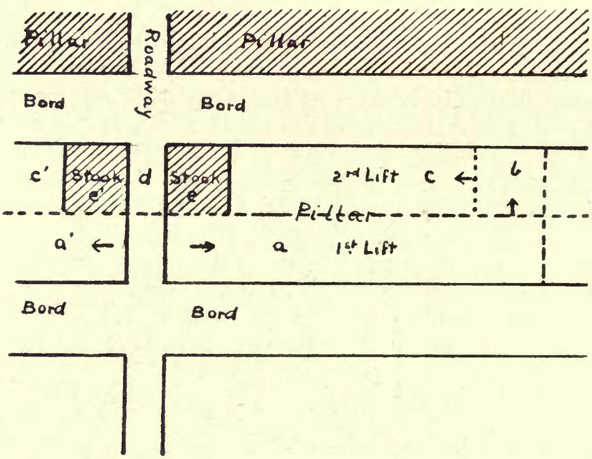

Fig. 188.—Pillar Drawing.

the working from one being in advance of the other, so that the different parties of men shall not meet half-way, and leave a large unsupported space open, which might cause a disaster. Each half of a pillar is again divided by an imaginary line, but this time it is halved lengthways, instead of across. The pillar coal is then worked in two lifts, as shown in Fig. 188. The lift (a) is taken out to the limit of the imaginary cross-line; the men then turn round and work out (b), in strips of 3 to 4 yards wide, after which they extract (c) as far as the stook. When the whole of the pillar has been extracted from both ends, except the stooks, the coal is dropped from the roof of the roadway (d), between the stooks, and finally the stooks (e) themselves are taken out. The top coal in the adjoining

bord is then dropped, and preparations are made for drawing the next pillar as in the previous case. The posts that support the roof temporarily are drawn as far as possible for future use before the workings in which they stand are abandoned. By employing plenty of posts, less timber is lost through crushing than if one is more sparing in its use. The posts have lids or slabs wedged tightly between them and the roof; the wedges may be driven in from any direction. If the post is not quite long enough, one may use two lids, and drive wedges in between them. Where the ground is "made," i.e., the roof has fallen in, sole pieces are used for the posts to rest on.

In many cases it is immaterial whether the surface of the ground above the workings of a colliery is allowed to subside or not, but in other cases, where buildings, railroads, reservoirs, etc., are overhead, the workings must be properly supported. Much of the ground mined by the A.A. Co. underlies the city of Newcastle, and on more than one occasion a subsidence has taken place, much to the alarm of those who own house property in the affected area. A Royal Commission was appointed to enquire into the last subsidence, which took place on 17th January, 1908, when damage was done to various surface buildings, the obelisk reservoir, footpaths, gas main, service pipes, sewer, etc. The creep area was about 100 acres, and under this about 65 acres of the yard seam has been worked, partly by the Government in the early days, and partly by the A.A. Co. This yard seam is 2ft. 10in. thick, and lies 170ft. above the borehole seam. The borehole seam under this area is practically worked out, except the pillars left, which amount to 60 per cent. of the total seam. The greatest depth of cover above the borehole seam in the disturbed area is 450ft. The Commissioners considered that the third creep was a continuance of the first and second creeps, and that the movement in the workings of the borehole seam would not in itself have been sufficient to cause the damage, but was intensified on the surface by the old excavation in the yard seam. The size of pillars it is advisable to leave in those cases where the surface must be left intact is one that must always be left to individual judgment, for one can never hope to obtain sufficient reliable data to enable one to make exact calculations. The strength of the coal varies, even in the same seam, some bands of which it is composed being softer and more pliable than others, and such weak bands really determine the strength of that particular coal. Then a pillar which is strong enough in limited workings, may not be sufficient to support all the weight thrown upon it when the workings are extended, and lateral support is nil. The presence of dykes and faults, by interfering with the continuity

of the seam, and adjacent rocks, causes the overlying strata to bear more heavily on the pillars that are left. When rock is broken up to, say, the size of road metal, it occupies about one-third more space than it did before it became broken up. At first one might think that it would be a simple matter to calculate at what height a crush of a certain amplitude would cease to affect the overlying strata. But those accustomed to mining operations are aware that though some of the roof may break up into slabs, and comparatively small pieces, the rock overhead comes down in large bodies, consequently the effect of a crush may be far-reaching.

The main and tail rope system of haulage is used in the mine, a set of skips travelling at the rate of 8 miles an hour. The driving engine is one of Tangye's duplex engines, with Cornish valves, 32in. diameter cylinders, 4ft. stroke, and the drums are 6ft. in diameter. To guide the rope on to the drum, there is a lever, with a sheave at one end, while at the other is a cord manipulated by the driver.

At the bottom of the shaft are four double 8¼in. cylinder Worthington pumps, and a Tangye pump with a 12in. working barrel and a 4ft. stroke, worked by steam conveyed from the surface; the exhaust escapes up the fan shaft.

The fan is a 13½ft. Schiele, with blades 4ft. wide, which revolves 120 times per minute; it is belt driven from a Walker's engine, of which there is a spare duplicate. The overcasts are made of wood, the joints are cemented over, and the whole covered with a layer of 3in. of sand as a protection in case of fire.

There are two ambulance cabins below, which contain stretchers and a box of first-aid appliances.

The men and horses enter the mine down a slope cut in the rock at an angle of one in six.

The winding engine is on the first motion, and was built by the Grange Iron Co., Durham, England. The cylinders are 26in. diameter, the stroke 4ft., and the drums 8ft. 8in. in diameter. The valves are of the Cornish type. Band brakes are arranged on the outside edge of the drum, but there are also steam brakes. There is a white mark on the top of the cage, and also on the side of the shaft frame, so that drivers can see when the cage is in the proper position at the surface. Side rail guides are fixed in the shaft. They have a butt joint, and are kept in position by a stretcher plate bolted to the buntons, and clips to hold the rails are bolted to the stretcher plate and bunton. A Walker's safety hook, for a load of 4 tons, is used in case of over-winding. This hook differs from most other safety hooks in principle, inasmuch as with the Walker hook the load tends the whole time to cause detachment, but is prevented from doing so by

a ring that encircles it. Fig. 189 shows the hook both closed and open; (a, a¹), are the two levers pivoted on (b), and held in place by the collar (c), and copper rivets passing through to a tongue piece. When the hook is pulled up through the thimble, the collar (c) is pushed down, the copper rivets sheared, the weight of the cage and load cause the jaws to open, and the wings catch on the top of the thimble.

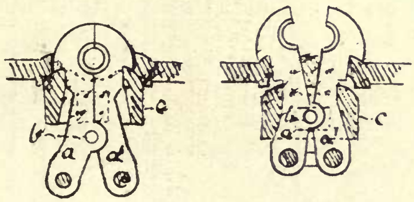

Fig. 189.—Walker's Safety Hook.

The coal is tipped from an end tipple on to a shaking screen, the top part of which is covered with sheet iron; then there are some bars, and finally thick iron wire mesh. The slack is weighed on a Billy Fair Play, and then stored in a coal box, to which it is taken by a conveyor, when there are no trucks ready to train it away. The round coal is weighed on two Avery machines. Beams are placed across the platform of the machine, and rods from these pass down to a box below, into which the coal falls from the end of the picking belt. The tokens, as they are taken off the skip, are clipped to a small carrier, and pushed along a wire leading to the weighing-room.

Hetton Colliery.

This colliery is situated at Carrington, a suburb of Newcastle, and is owned by the Hetton Coal Co. Ltd. It is about 24 years old, and has been for many years under the charge of the present manager, Mr. A. Mathieson. The coal mined is under the ocean and tidal waters, and one of the interesting features of this colliery, as also that of the adjoining Stockton colliery, now closed down, is in connection with shaft sinking through quicksand and clay. The shafts are 280ft. deep, and are tubbed from the surface to within 60ft. of the bottom. The main shaft is 15ft. 10in., and the air shaft 14ft. in diameter. The thickness of the cast iron segments which go to form the rings is the same from top to bottom, namely, $1\frac{1}{4}$in. There is a slight difference in the styles of the tubbing in the two shafts. The segments for the main shaft were rough castings, with only a 1in. face at the back, where the segments above and below were able to come in contact, the rest of the joint being occupied by half-inch thick lining boards,

well soaked in red lead; the object of letting a portion of the iron rest on iron was so as to keep the wood in place, and not to let all the weight come on the bracket of the casting. In the case of the air shaft, there was a machine-planed face three inches wide, and the joint was made with red lead, which made a good fit. The ordinary segments were three feet high, and were connected together with bolts from the inside of the shaft, and as all the flanges and strengthening brackets were also cast on the inside, this left the outside smooth, so

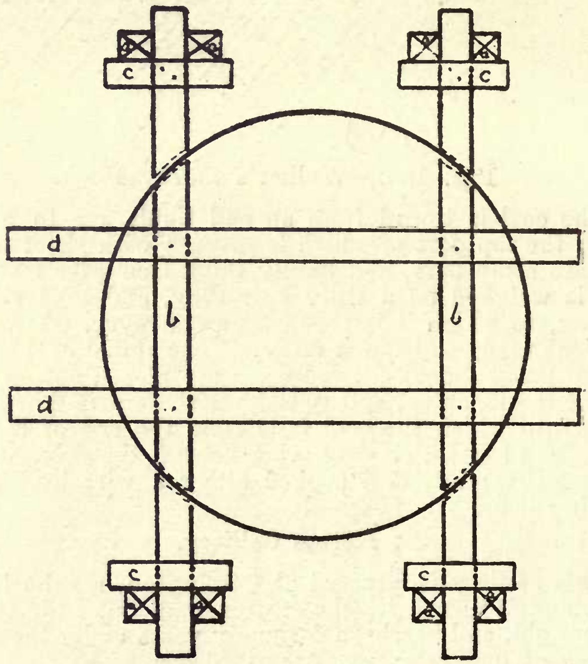

Fig. 190.—Frame used when sinking shaft lining.

that it could pass down through the strata without any obstruction. At the bottom of the tubbing was a shoe or cutting edge. This was a ring similar to those above, only it was but one foot deep, and instead of a flange at the bottom it was bevelled off. The successive rings were put together on the surface, and forced down by weights piled on the top. First, four pairs of vertical posts were put in position, as shown at (a), Fig. 190. These acted as guides to two horizontal beams (b), which were notched where they rested on the tubbing. Small pieces of timber (c) were bolted on to

these beams at right angles to them, near the guide posts, to help keep them in place. Two long beams (d) were bolted on to the first beams at right angles, and on these were stacked a heap of railway iron pig-sty fashion. The deeper the tubbing sunk the greater the friction, and consequently the greater the weight required, until eventually it reached 1000 tons. At about 50ft. from the surface in the downcast shaft, the tubbing passed into clay, and the man in charge, thinking it would be safe to add any further rings to the bottom, inside the shaft, instead of to the top and forcing down the whole lining, gave instruction for the water to be baled out. Unfortunately, the tubbing was not down far enough into the clay, so when the support of the water and sand from the inside was taken away, the tubbing burst, and quicksand rose in the shaft. As the original tubbing could not be driven down any further, it had to be telescoped. The smaller diameter tubbing was forced down in a similar manner to the other; only a square wooden frame was built on the top, at the corners of which were posts 30ft. long. This enabled the tubbing to be weighted at the surface; but fresh rings were added inside the shaft above water level. It was only found necessary to have 20ft. of the smaller diameter tubbing, and then the shoe was taken off and a bell-shaped ring added from below, so as to bring the shaft from there onwards to its original diameter, thereby minimising the friction of air due to a constricted passage. The rest of the tubbing was put together from inside the shaft. It used to take six men a shift of 10 hours to dig out three feet of clay, and put in a ring of tubbing. When putting in the tubbing, not only were the vertical joints of adjoining rings made to break joints, but the different rings were begun and ended at various places, so as not to have a continuous line of weakness in any one part of the tubbing. The joint between the inner and outer tubbing was made water-tight with cement. When sinking the tubbing from above, the sand and water was removed by a bucket 2ft. in diameter and 4ft. long, with a clack at the bottom 5in. square. This was worked up and down till full, and then drawn to the surface. This sand-pump was found to work better when a few inches of piping of ample area was fixed below the clack. Later on, when the rings were added to the lining from below, and loose sand was met with, it was found advisable to use segments one-eighth the size of those generally employed, as they were easier to handle. When replacing the shoe, two segments were taken out at first before a new one was inserted, after which a segment of the shoe was taken out for every new segment put in, so as to leave room to work in easily. The last new segment had to have one end pushed in at the back

before it could be drawn into place, since the outside of the casting is of greater diameter than the inside.

A. A. Atkinson gives an account of the sinking of the No. 3 pit of the Stockton colliery,* from which the following is taken. The total depth of the shaft is 290ft. 4in. to the bottom of the seam. The shaft is tubbed to a depth of 281ft. 2in. The time occupied in sinking the shaft, including all delays, was about 3 years and 8 months. The first 233ft. 9in. were forced down from the surface; the rest were inserted by undersetting. One hundred and thirty-five feet six inches of the tubbing was 10ft. inside diameter, but the last 145ft. 8in. was telescoped to 8ft. 10in. To start with, an excavation 22ft. deep was made, and supported in the usual way by piling and boarding. The object of this was to give greater facility for building the rings and to enable a length of 21ft. to be forced down in one operation. All tubbing was made of 1¼in. thick cast-iron, and 3½ft. high: the strengthening ribs 1 1-8in. wide were placed on the inside, so that the outside could be forced down through the alluvial with the least possible re-

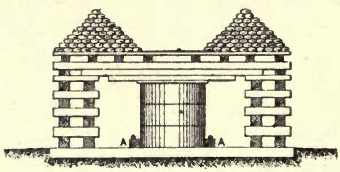

Fig. 191.—Method of forcing-down Cylinders.

sistance. The 10ft. diameter tubbing was constructed of rings made of 8 segments, while the rings of the 8ft. 10in. tubbing was composed of 6 segments. A strong framework was erected at the top of the shaft to act as a guide to the cylinders, and oblige it to sink down as vertically as possible; it also permitted six rings to be fitted together at a time on the surface. The bottom ring was provided with a cutting edge, so as to force its way through the alluvial. In order to obtain the necessary pressure to force the cylinder down, sand bags were piled up on a platform resting on the cylinder; this weight had to be properly distributed. The platform was built up as follows:—Planks of soft wood were placed next the iron to act as a cushion; on these, in three tiers, each tier increasing in length till the topmost one was about 40 ft., were placed balks of hardwood timber 14in. square. Fig. 191. These main balks were arranged in pairs at the

*Working Coal under the River Hunter, the Pacific Ocean and its Tidal Waters, near Newcastle, in the State of New South Wales. (T.I.M.E., 1902.)

required distance apart, and the top tier was crossed by others at right angles, leaving a square opening at the centre of the shaft for the free passage of the sinking bucket. These balks were decked over, and on the decking were placed the bags of sand, until the desired weight for the time being was obtained. Safety chocks were built up to prevent the cylinder from slipping down suddenly while the divers were working at the bottom of the pit: (a) are guides to assist the cylinders to sink down vertically. During the process of sinking the cylinder, when the resistance of the strata was sufficient to balance the loading, a 400gal. tank was fixed at the surface, from which a pipe led down to the bottom of the shaft, as the water was baled from the shaft, it was discharged into the

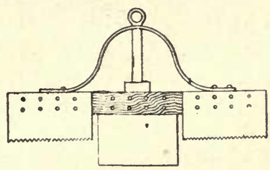

Fig. 192. Trepan—Side Elevation.

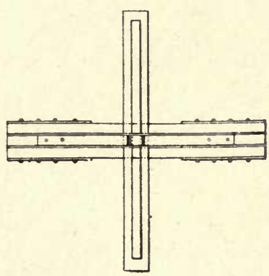

Fig. 193. Trepan—Plan.

tank, and returning through the pipe acted with sufficient force to stir up the sand. This caused sand on the outside of the cylinder to have a downward movement, and by disturbing the equilibrium, caused a further sinking of the tubbing. In spite of the care taken to make the cylinder sink vertically, when at a depth of 60ft., it was found to be 18in. from the perpendicular, so the work of re-adjusting was performed by securing the edge of the lower end to a powerful screw by means of chains, and this was supplemented by shores kept tightly wedged to the lower side. Water was then led down from the 400gal. tank to stir up the sand, and in a short time the cylinder was restored to a perpendicular position.

At a depth of about 149ft. 8in., a strong blue clay was encountered, and its resistance was sufficient to prevent the further sinking of the cylinder by the above-mentioned method, so a trepan, or chopper, was devised by the management made of bar-iron, wood and boiler-plate, and was fitted with four knives at each end, and two in the centre. Figs. 192 and 193. This was worked percussively, and cut up the clay so that it could be filled into buckets by the divers. Until this clay was met with, the water rose and fell in the shaft at the same time as the tides. When a diver intended to operate, the water was baled out to a minimum depth over the diver of 60ft., this head of water being necessary to prevent any inrush of alluvial while the diver was working on the bottom. The diver worked under water from two to four hours at a time, the period being generally limited by the rising of the water in the shaft to a maximum of 110ft. While operating, the safety chocks were placed under the ends of the weight bearers to prevent any undue or sudden sinking of the cylinder, resulting from the removal of the clay. Too much clay must not be taken out at a time, neither must it be removed from too near the edges of the cylinder until the cylinder has been sunk further down. At 135ft. 6in. the lateral pressure and adhesiveness of the alternating clay-beds was so great that it was considered inadvisable to increase the weights, which then amounted to 1400 tons loading, and approximately 162 tons 14cwt. of cylinder, for fear any additional weighting might have seriously fractured the cylinder and caused a collapse of the shaft, so it was decided to reduce the diameter of the shaft by telescoping it. To get an idea of the strata to be passed through, two boreholes were put down by churn drills. The shaft was then filled to the top with sand, and the work of telescoping commenced. At 165ft., a hard agglutinated mass of shingle 7ft. 6in. was met with, which gave trouble, as the size of the stones were very variable, and consequently caused unequal resistance to the downward movement of the cylinder. The inner or telescoped portion of the tubbing was sunk from the surface in a similar manner to the outer tubbing. A water-tight connection was made between the inner and outer lining by drilling holes through the cylinders, and running cement through them till it solidified.

The winding engine at the Hetton colliery was made by Davidson, of Durham, England, and has two 26in. diameter cylinders and 4ft. 8in. stroke. Besides the ordinary dial depth indicator, there is a knocker indicator, which shows the number of knocks that have been given on the face of a dial, so that there shall be no mistake in case the engine driver miscounted the knocks. At the end of the knocker line is

a rod, kept in tension by a weight; on the rod is a hinged finger, which is stiff when anything presses on it from above, but which is pushed back when pressed against from below. A horizontal axle has two wheels, and an indicator hand attached to it. The larger wheel has cams on its periphery, by coming into contact with which the finger on the rod can turn it. The smaller wheel has a cord attached to it with a weight at the end, which is the motive power that fetches the hand back to zero again. Ten men are raised or lowered at a time in a double cage, and six in a single cage.

The mechanical haulage below is on the main and tail rope system; there are two of these. The distance hauled is 1½ miles, which takes 10 minutes to accomplish. Eighteen to twenty sets of skips are run in and out a day. The tail rope is attached to the end of a set of 64 skips by a slip hook. As a set of empties coming in approach the end of their trip, a lad jumps on the buffer of the first skip, and pulls out the pin that releases the hook, leaving the tail rope opposite the last skip of the full set on a parallel line. The inertia of the empties pulls the main rope opposite the first skip of the full set. This is necessary, for the incoming set is pulled out to its full extent, while the empties, having been pushed one against the other, are buffer tight, so that it would cause much trouble and delay to manipulate the rope otherwise. The main and tail rope engine has a pair of 30in. cylinders, and a 5ft. 6in. stroke. There is a clutch between the 7ft. drums, which connects one drum with the shafting, while the other runs free. The driver knows by the position of the ropes on the drums when he can increase or must decrease the speed. The skips are brought to the make-up station by horses. A heavy pointed iron rod known as a "bull" is attached to the last skip of a set. This is kept from dragging on the ground by a hook, which holds it on to the tail rope, but when the tail rope becomes slack, it digs into the ground, and prevents the set of skips from running backward down hill.

The electric plant consists of a compound-wound British Westinghouse direct-current generator of 100kw., built to carry 200 amp. at 570 volts. This is belt-driven, at a speed of 600 r.p.m. by a compound Westinghouse engine. This plant is used for electric lighting and also for some pumps.

There are three electrically-driven triplex Gould pumps, one with a capacity of 32,000gal. per hour, and the other two of 25,000gal. per hour. The larger one is connected with its motor by a rope drive; the others by gearing.

There are also several air-driven pumps, of Tangye and Worthington make. The air-compressor is a duplex Tangye, with a 23in. diameter steam, and a 22in. diameter air cylinder.

The Guibal fan is 30ft. in diameter, and 10ft. wide. It is given 50 revolutions per minute. This is driven by an engine, built by J. S. Rodgers, of Newcastle, N.S.W., which has a 20in. diameter cylinder.

Tallow is burnt in the small lamps used in the working places.

For testing the thickness of the rock overhead, between the seam and the ocean, they use a Diamond Drill Co.'s double-handed machine (Fig. 194), but instead of a bit set with diamonds, they either use an auger or a serrated steel bit, which gives a core. The core bit is only used for hard ground,

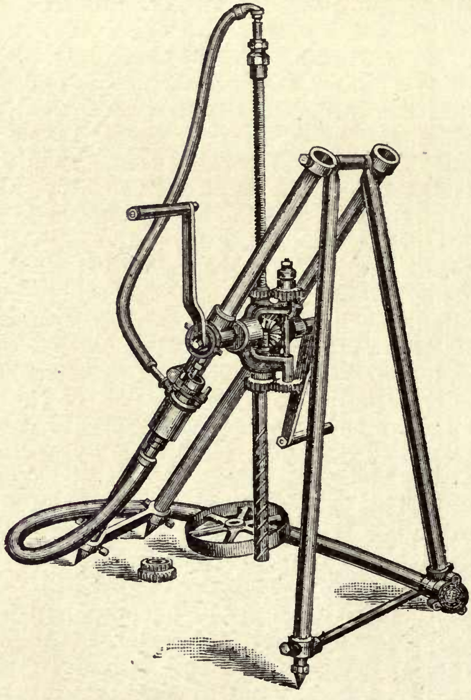

Fig. 194.—Rock Drill.

and for the last few feet of boring; the gear, regulating the feed, can be changed as desired. A hand-pump is used to pump the necessary water up through the drill. This machine can be easily taken to pieces for convenient handling in confined places. Originally this make of drill had the rods coupled direct to the lower end of the spindle; now they are made with the spindle or screw shaft of such a diameter as to

allow the passage of the rods and core barrel through it, and carries at its lower end a chuck, which clamps the rods firmly to the spindle. After feeding the spindle forward through its full run, the chuck is released, and the spindle fed very rapidly back to grip the rods higher up. For underground work, extension screws may be fitted into the top of the two parallel columns for jacking up against the walls of a tunnel, in which case the back legs are removed. To save pumping by hand, the pump may be mounted on one of the columns, and be worked by an eccentric on the main crank shaft, as shown in the figure.

Stockton Borehole Colliery (Boolaroo).

This was formerly known as Black's colliery, and was worked by the Sneddons. It now belongs to the old Stockton Co., and is under the management of Mr. A. Hindley.

The borehole seam is thin in this part of the field, being 3ft. 9in. to 3ft. 10in. thick, so is worked on the longwall system. There are two shafts, about 750ft. deep, the downcast being 16ft. in diameter, and the upcast 14ft.

The air shaft is protected with light wooden roof-shaped doors, counterbalanced by weights connected to them by ropes, so that in case of a gas explosion in the mine they can be easily blown open. While sinking, the usual lorry or running bridge was used as a shaft cover, on to which the buckets were landed. Two wire-rope guides were used for the cross-head, while sinking, which terminated about 50ft. from the bottom of the shaft. These rope guides were lowered as required from reels, with the assistance of differential block and tackle, and when at the desired depth, they were held by an iron clamp connected to an eyebolt, which was fixed in concrete.

The hoisting engine is duplex, with 22in. diamerer cylinders and a 5ft. stroke. It has a conical wood-lagged drum, with 12ft. 6in mean diameter. Cornish valves are used for both steam and exhaust, and are actuated by trip gear. Cornish valves have a quicker admission and cut off than slide valves: the main objection to the Cornish type being the hammer on the valve due to it dropping by its own weight, and if the valve is badly packed, it may hang up, and become unreliable. The steam cylinders have spring relief valves at their ends to let any water escape that may have collected by the condensation of steam, thus saving damage to the cylinder in case the pet cocks are not properly attended to. They have Cornish, Lancashire, and Babcock and Wilcox boilers for raising steam.

The air compressor is a single stage compressor, made by Oliver and Co., of Chesterfield, England; the steam and air cylinders, both of which are water-jacketed, are placed parallel with each other. Spring valves are used for the air inlet valves.

For ventilation, they have one of Waddle's patent fans and engine. The fan is trumpet-mouthed, and is 28ft. extreme diameter. The engine cylinder is 22in. in diameter.

Water is pumped from 230ft. down, where there is a lodgment: from the bottom of the shaft, the water is bailed. An Evans' pump is being installed. They have to use safety lamps underground.

One of the most interesting features about this colliery is the fact that the original steel head frame, when erected, was found to be too short, as the coal could not be raised sufficiently high for screening and subsequent operations, so the whole structure was raised bodily 14ft., and the additional length added to the bottom. First of all, the back stays were disconnected, also the cross-stays at the top, which connected them to the main structure, and they were supported in position by a cross-beam placed under the back stays, and a long post in the middle. Bearers were placed on either side of the four main legs, thus connecting them in pairs; and these bearers were well bolted together. Other beams were placed under the bearers, and at right angles to them. Hydraulic jacks were then placed below, and the whole structure raised evenly. Guy ropes were used to steady the head frame as it was being raised. As the structure was lifted from the ground, pig-sty timbering was placed beneath to support it. The angle iron of the original and added lengths were butted together, and bolted to fish-plates, 2ft. 9in. long, placed on the outside. On account of the splay of the legs, the concrete base to which the legs were fastened by eight bolts, had to be built further out than those used for the original shorter head frame. The back stays were then lifted up, and connected with the main structure, the extra length added to the bottom of them, and fastened to concrete piers by six bolts. The back stay supports were then connected up. The bottom part of the built-up steel legs was filled with concrete raised slightly in the centre, so as to prevent water lodging there.

The pit-head pulleys were made strong enough for the work required of them. The plummer blocks have large bearing surfaces, the spindles of the pullies being large so as to reduce the pressure per square inch of surface. Brasses are on the lower half of the plummer block only, where all the wear is, there being no occasion to have any lining on the top. The spindle is lubricated automatically by means of a loose steel ring, which encircles it, and is caused to revolve

on account of friction; the lower part of the ring dips into an oil chamber, so when revolving it brings up some oil. The oil, which finds its way out at the end of the spindle, falls into a recess connected to the body of the plummer block by a port. A tap enables the oil to be drawn off when it becomes too thick. A cap is placed over the outer end of the plummer block to keep out the rain. The lubricant is replenished once a month.

At the bank, the skips of coal are weighed on an Avery turntable weighing machine, Fig. 195. The rails are given a down grade to the tippler, of 1 in 60, so that the skips can run down hill alone. The empties are taken up hill again by

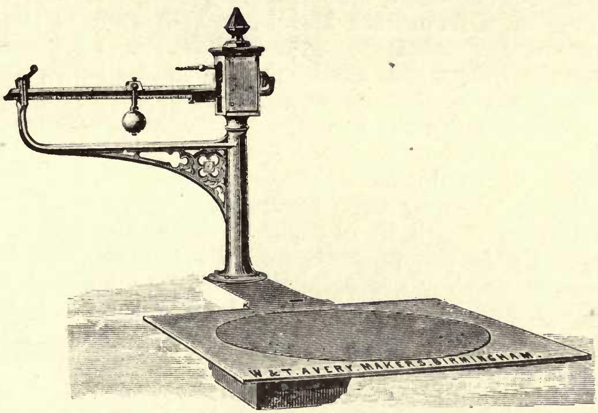

Fig. 195.—Avery Turntable Weighing Machine.

a creeper chain. The side tipplers tip the coal on to a shaking screen, placed at an angle of 1 in 4; from that the round coal passes into a picking belt, while the slack falls into a small hopper skip, and is carried up to the storage hopper.

Dudley Colliery.

This colliery belongs to the Dudley Coal Co., and is under the management of Mr. G. Thompson. It has been working for about 17 years on the bore hole seam, which is here 6ft. 3in. high and in which there are two bands of dirt; but only 5ft. 9in. are extracted, 6in. of dirty coal being left in the roof.

The downcast shaft is 624ft. deep, and the upcast 553. The cages run on rope guides, two on the outer side and one on the inner side. There are besides two dead ropes between the cages to prevent the latter swaying too much.

Operations are carried on under the ocean. A five chain barrier pillar of coal is left between the ocean and land workings, the former extending for 700 yards past the barrier. There are 131ft. of solid rock overhead, though the depth of cover required by law is only 120ft. The ocean workings have bore holes put in advance, not less than 15ft. in length, and at every 20 yards driven, bores 30ft. high are put in the roof to test the rock overhead.

The mine is dry and dusty, and is worked with picks only, on the bord and pillar system. The picks weigh 2½ to 3½lbs.

At 9 a.m. on 21st March, 1898, there was an explosion, causing the death of all in the mine at the time, viz., 15 men, including the manager and two deputies. On account of the fire that took place after the explosion, the mine was temporarily sealed down from 24th March, to 17th June of that year. The Court of Investigation found that the explosion was caused by the ignition of firedamp at a naked light, and that it was intensified by the agency of coal dust. Since then the Cambrian safety lamp has been used, in which are burnt three parts of colsa and two parts of kerosene oil.

Prior to the explosion they worked with 8-yard bords and 8-yard pillars, but now they work with 8-yard bords and 12-yard pillars, as it will be cheaper to work the larger pillars later on. Up to the present, no pillars have been worked. Under the ocean they are compelled to have bords not wider than 6 yards, and to have pillars at least 8 yards wide.

Air is circulated by means of a 30ft. Waddle fan. A white mark is painted conspicuously on the fan, so that the manager can see from a distance whether it is revolving at the proper rate. This is the more necessary since the upcast and downcast shafts are situated further apart than is usually the case, and intervening trees somewhat obscure the view. The fan is given 48 to 50 revolutions per minute, the pressure of the air being one inch water gauge. The fan engine is duplicated in case of accident. There is a lever by means of which the valve can be pressed close against the valve seating of the steam chest as they wear, thus preventing leakage of steam.

The haulage below is all done by horses. These are stabled at the surface, and sent below every day. Gates are put on the end of the cages when raising or lowering horses, but there is no occasion to tie them up when once they become accustomed to travelling in a cage. There is a well-appointed saddler's room at the surface, in which a saddler is employed mending and making harness.

The well-known Humble's safety detaching hook is used in case of over-winding.

The hoisting engine is duplex, worked on the first motion, with slide valves, cylinders 26in. in diameter, and a 4ft. 6in.

stroke; the brake is worked by foot. The drums are conical —not spiral—being 12ft. and $13\frac{1}{2}$ft. in diameter. The drums are lagged with tallow wood, which has been previously treated for three years by painting it over with a mixture of sea-water and blue oil about once a week, until it is so hard that an adze will hardly touch it. The engine driver is so situated that he has a good view of the shaft, and the windows of the engine-house are placed so high that the driver's attention cannot be distracted by watching anything that is going on outside. There are four Cornish boilers coupled up together. The feed water is heated by pumping it into a vessel into which the exhaust steam is led.

The coal is weighed on Avery weighing machines, capable of weighing two tons. There are two jockeys on the beam; one for the tare, the other for adjusting the weight. The coal is tipped from an end tippler on to stationary screens. There are two gates attached to a lever, for easing the coal down on to the picking belt after a skip full has been tipped on to a screen.

Burwood Colliery.

This colliery originally belonged to the Burwood Coal Company, who started sending coal to market in 1885 from the old pit, and continued mining operations till 1894, when the Scottish Australian Mining Company took possession. It is now under the management of Mr. F. H. L. Croudace, who has been in charge since 1896.

The borehole seam is worked at this colliery, which to the north of the estate has the following section, commencing at the top:—

Coal	2ft. 8in.
Band	1in.
Coal	2ft. 6in.
Band	1in.
Coal	1ft. 1in.
"Mogan"	4in. to 8in.
Four-inch Coal	6in. to 8in.
Band	1in. to 2in.
Little tops Coals	8in. to 12in.
"Jerry"	3ft. to 4ft.
Sandstone	

To the south of the estate the section is

Coal	2ft. 6in.
Band	1in.
Coal	2ft. 4in.
Band	1in.
Coal	1ft. 0in.

below which there is nothing of commercial value.

It is all pick work in this mine; no machines are used.

There are two endless ropes; one running north for two miles, the other south; they travel at the rate of two miles per hour. The southern rope serves two districts. Later on they will have a band rope down the shaft, and work each district by its separate rope.

The colliery is unwatered by a Tangye pump, also by a rope driven pump, which delivers water to the old Burwood shaft.

The Walker's fan is 24ft. in diameter and 7ft. wide. It is run with cotton ropes, and geared 2 to 1. Cotton is found to be more durable though more expensive in first cost than manila rope. The engine that drives the fan is compound, so arranged that one-half of it can work the fan if necessary. It is driven with 100lbs. steam pressure, and makes 40 revolutions per minute.

The shafts are both 15ft. in diameter, and 600ft. deep; they are lined with brick when in soft ground. A compensating balance is used between the safety detaching hook and

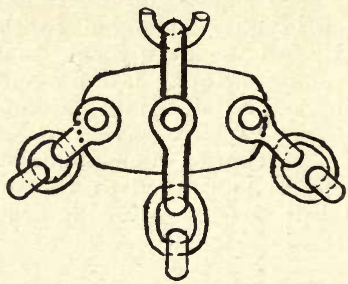

Fig. 196.—Connection for Bridle Chain.

the bridle chains which consists of a plate capable of moving on a central pin (Fig. 196), so that it can equalise the strain on the chains attached to it. The cages run on rope guides, which are clamped at the top with three clamps. On account of corrosion at the bottom of the pit, the ropes became too short, so were lengthened from the top by means of rods.

The winding engine has a 10ft. drum, 24in. diameter cylinder, and 4ft. stroke.

The full skips at the surface are run into Tate's water balanced tipplers (Fig. 197). The skips are prevented from running out at the far end of the tippler by long hooks which catch in the front axles, and when tipped over sideways, the skips are prevented from falling out by angle irons that keep the wheels on the rails. The water-tank underneath the rails is so weighted that it more than counterbalances the top part

of the tippler and empty skip, and consequently causes it to right itself again, a brake being used to steady the tippler.

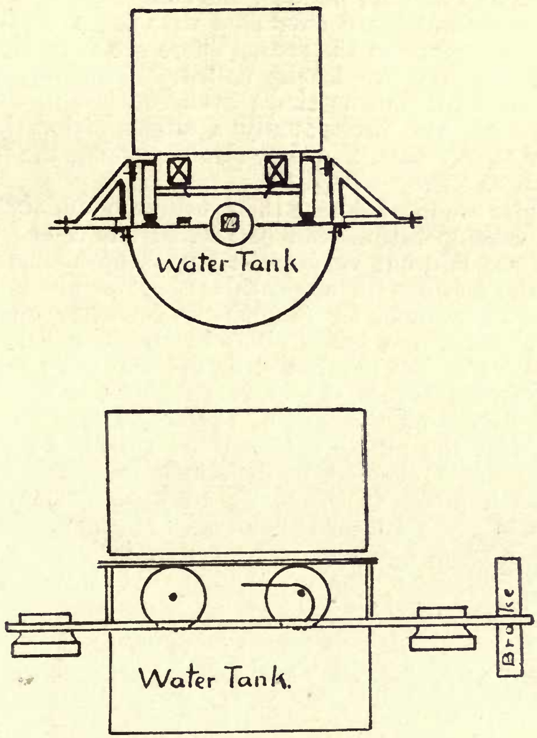

Fig. 197.—Tate's Water Balance Tippler.

These tipplers tip the coal on to two picking belts, from which the coal passes to shaking screens. The round coal drops into waggons standing on 15-ton weighbridges, while the slack is conveyed into storage bins.

Lambton B. Colliery.

This colliery, which was formerly known as the "Durham," belongs to the Scottish Australian Mining Company, and has been under the management of Mr. Sydney Croudace since 1898. The nearest township is Dudley, which is reached from Newcastle by coach, but workmen's trains run between Newcastle and the various mines of the district, morning and evening.

The seam being worked is the borehole seam, which here is about five feet thick. This is the furthest south mine to work the borehole seam extensively, as it gets thinner to the south; and as the two bands in it continue, this makes the seam relatively dirtier; besides, the coal itself is not so clean. The whole of the seam is extracted with the exception of four inches of dirty coal on the roof. There are very distinct main cleats, or, as they are locally called, "jerry faces," cutting through the coal, and at times even continuing through the roof and floor, and occasionally a slight dislocation will be found at a "jerry face." Minor cleats crossing the main cleats are known as "grey backs."

The pits are located near the southern boundary of the property, so that operations can be carried out to the rise. The workings are laid out very regularly. The main intake goes towards the ocean with a return airway on either side of it. The mine is planned on the panel system; each district is 23½ chains wide, and has a pillar of 16 yards between them. Headings are driven parallel with the main cleavage. Cross-cuts are driven across the cleavage at an angle, while the bords are driven on the face of the cleavage. The bords are 6 yards wide, the pillars between them being 16 yards wide. The bords are connected by headings every 40 yards, thus making each pillar 40 yards by 16 yards. The pillars are extracted in steps 10 yards behind each other, the most forward one worked being in-by: the coal is worked in 8 yard lifts. The pillars follow up about two headings behind the working in the whole.

The Ingersoll pick or punch machine is used in a portion of this mine, and eventually the coal will be worked entirely by machines. The size of the machine used is "F4." The undercut is 12 to 15 inches high in front, and tapers towards the back, which is 4ft. in. By making a wedge-shaped holing the coal when blasted down falls forward as with ordinary pick holing, and is much less trouble to fill than if the cut was even all the way through, when the coal would tend to drop down in a body. This machine is considered to be more suited for this particular seam, as it can work round nodules of brasses. The machine runner can tell by the way the coal cuts, when he reaches a main cleat, but he keeps on for his full four feet deep, and trusts to the shots to break down the coal to the best advantage. Should the coal break off from a cleat before reaching the end of the undercut, possibly the remaining coal may be so loosened that it can be brought down by a few blows of a pick; if too solid, then the undercut is so much towards the next round. One machine will work five places from 6 to 7 yards wide in an eight hours' shift. As

soon as one cut across is finished, the machine is placed on a trolly and conveyed to another face, while three holes are drilled in the place just left, one in the middle and one at each side, about 3ft. 9in. deep. The holes are drilled by a hurdy-gurdy hand machine about six inches from the roof; they are directed slightly upwards and sideways, so as to give a lift to the shot. The coal being soft, the auger type of drill works much quicker, and with less trouble, than the ordinary hammer and drill used for rock. A nich is made in the

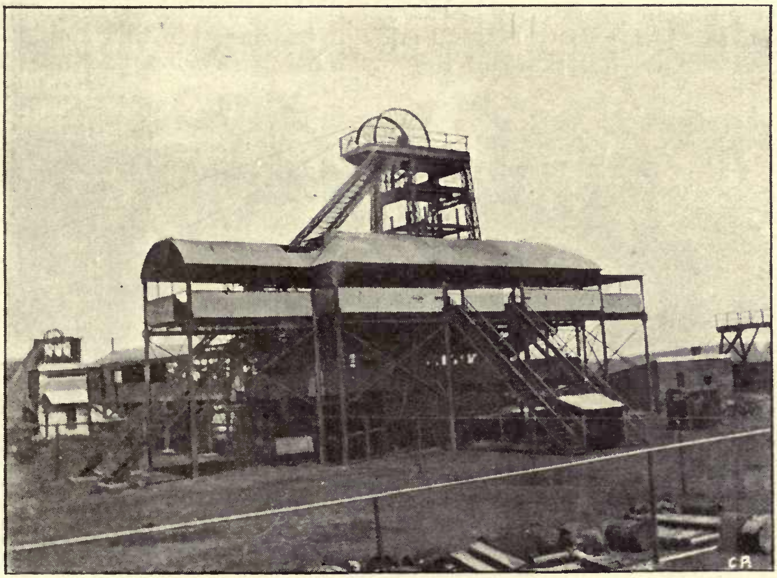

Fig. 198.—Headgear of Downcast Shaft.

roof about 18 inches from the face, into which one end of the jack screw at the top of the standard fits. This standard is made of two notched sides, and in these notches fit trunnions fixed to the side of a nut. A threaded rod (at one end of which the cutter is attached, while at the other is a handle), passes through this nut. The turn of the handle not only causes the bit to cut, but gives the screwed rod a positive feed forward. When drilled, the three holes are charged, the centre one with 5oz. of monobel, and the two back ends with 4oz. Only one shot is fired at a time; first the centre shot, and subsequently the back ends in turn. The firing is done by an electric battery, of which they have two types, one by Davis, of Derby, the other by Nobel.

The pit top, including the pit head frame, tipplers, screens and travelling belts are made of steel; but the bank is not attached to the pit head frame. (Fig. 198.) The skips are brought up two at a time, tandem ways, in a single deck cage, which runs on wooden guides at its ends, except near the top and bottom of the pit, when they are changed to the sides. On arrival at the bank, horns fixed to the top of the cage pick up two bars looped loosely round two small vertical ropes, one after the other. When a cage is below, these bars protect the mouth of the shaft. The lower portion of the rope on which the bars slide has gas piping round it. The loops of the lower bar are large enough to pass over this and rest on collars, but those of the upper being smaller, rest on the

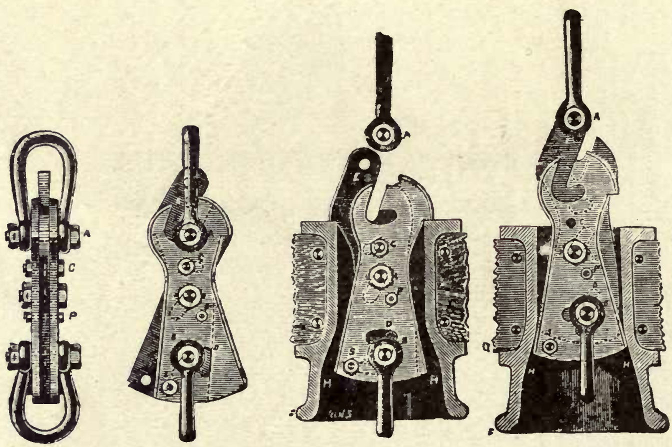

Fig. 199.—Ormerod's Safety Hook.

top of the piping, which thus serves to space the bars when at rest. An Ormerod's safety hook is placed above the bridle chains of the cage, and as an extra safeguard, in case of overwinding, serrated bars are fastened at each end of the sides of the cage, which engage with the projecting arms of an overhead chair, thus holding the cage up.

Ormerod's safety hook is shown in Fig. 199 A, B, C, and D. (A) shows a cross view of the hook, and (B) a side view of it, when in position for use, and under ordinary conditions the plates are held in the position shown by the copper rivet (p). In case of overwinding, the hook passes up through a cast-iron thimble fixed at the top of the head frame below the pit head pulley, and in doing so the wide portion at the bottom

of the hook is compressed. This shears the copper rivet, and causes the head of the hook to widen out, at the same time releasing the rope shackle as shown at (C), so that the hook from which the cage is suspended rests on the top of the thimble; in the meanwhile, the lower shackle, connected to the bridle chains, slips down into a slot and locks the hook in position, so that there is no chance of it slipping back through the thimble unintentionally. To lower the cage and hook again, the bolt of the rope shackle is passed through a hole in the top of the middle plate, the pin (c) is removed, and the rope wound up slightly, when it assumes the position shown in (D), so that it can be lowered through the thimble.

Full skips come up in one cage while the empties descend in the other. Two stopblocks are placed between the rails of the full track to prevent the skips from running back into the shaft. The skips are then taken up a short incline by a creeper chain, after which they shunt into a parallel line, run into a side tippler, and pass on the empty line towards the shaft. The skips are retained on this line by a squeezer till the cage is ready for them. This consists of a frame made of angle iron fixed at one end, but loose at the other. The bar on either side of the frame is made to press on the tread of the skip wheels by a weight, and can be lifted off to release the skip by working a lever with the foot. A greaser for lubricating the axles of the skips is located on the creeper chain track.

The steaming plants consists of a range of five high pressure Lancashire boilers at the downcast shaft, 7ft. 6in. in diameter; one is by Tangye, of Birmingham, the other four by Adamson, of Manchester. They are all coupled together. Besides the ordinary lever safety valve, these boilers are provided with dead weight valves, each disc weighing about 20lbs. At the upcast shaft, there are two 8ft. 6in. Lancashire boilers, by Walker Bros. A Green's economiser is erected at the back of the main range of boilers, but it is not used, for the work entailed in keeping them clean and in repair is not compensated for by the saving of fuel, when it is cheap, as at a colliery.

Berryman's feedwater heater is found to be the most economical under the circumstances, though it is by no means perfect for high pressure intermittent engines such as the winding engines, as can be seen and felt by the shower of spray that falls around it during winding. This heater consists of a nest of inverted U-shaped tubes in a shell. The exhaust steam passes through the tubes, so does not mix with the feed water; consequently, there is no fear of grease and dirt from the cylinders entering the boiler.

The main winding engine was made by the Grange Iron Company Limited, of Durham, England, and is worked on the first motion. The cylinders are 24in., and it has a 5ft. stroke. The valves are of the Cornish type, as they act quicker, and are easier on the hand than slide valves for large engines. There is only one drum, 12ft. in diameter, but two ropes are used on it. There is a band brake, the brake-path being lined with wood.

The present air compressor has duplex air and duplex steam cylinders; the former have spring valves, and are water-jacketed. This machine was also made by the Grange Iron Company, and is used for compressing air for the Ingersoll punching machine. There is no air receiver at the surface, as there is a great length of main piping, at first 8in. cast iron, and later 6in. diameter spiral riveted pipe, made by Mephan Ferguson, of Footscray, Victoria.

Some difficulty was experienced in sinking the two shafts, on account of quick-sand having been encountered. The downcast shaft, which is 430 feet in depth, had to have its upper 60 feet tubbed in consequence, while the upcast was tubbed for about 80 feet. There was trouble with the upcast shaft, for the tubbing got out of plumb, and also collapsed, when down a certain distance, so that a second tubbing had to be telescoped inside it, which made the diameter of the lowest portion of the shaft somewhat smaller than was originally intended. The inner tubbing was allowed to come above water level when finished, and the joint between the two was cemented up. The tubbing was built up on the surface, the different sections being bolted together on the inside, so that the outside was smooth to slip down. A shoe was fastened to the bottom ring of the drum, and the cast-iron lining was weighted on the top with sand bags. On passing through the watery strata, a seating was made in solid rock, which was carefully levelled and cemented for the wedging crib to rest on. The space at the back of this wedging crib was filled with blocks of wood and wedges driven in till a watertight joint was made, and the crib was in the proper position for the tubbing to connect up with it. The vertical and horizontal joints of the tubbing were then wedged up, and that section of the shaft was complete.

Each shaft has a 20ft. well hole, which is connected by a drift; that serves as a water lodgment. The water is raised to the surface by a Tangye steam pump with double 5-inch diameter plungers, which is located in a chamber at the foot of the upcast shaft.

At the bottom of the downcast shaft the brick walling reaches to the floor of the roadway. A by-pass is made on one

side for the men to travel through, so that they shall not be injured in case of anything falling down the shaft.

The roadways are timbered with caps and legs where support is necessary. Occasionally a cap piece will rest in notches cut in the wall, but the shale fritters away on exposure to the air, while the coal is unharmed, so frequently a place is cut out in the shale, in order to allow a punch prop to rest on the top of the coal, thus saving the timber of a full leg.

At present horses do all the hauling to the pit's bottom. One horse can draw five empty skips up hill, and any number of full skips down hill. The horses are raised to the surface

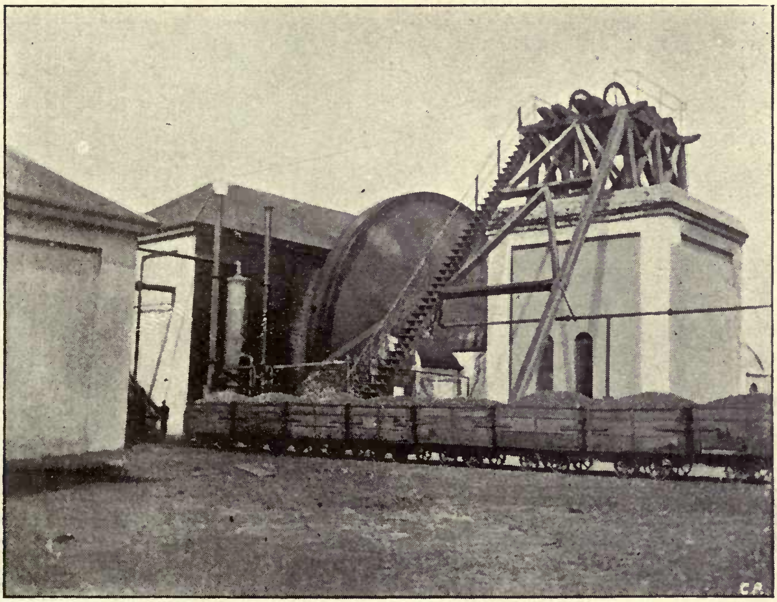

Fig. 200.—Upcast Shaft and Waddle Fan.

and lowered in cages every working day. Some of the shale has to be brushed down in the main roadways to give head room, making the roadways seven feet in the clear. The drivers are boys who drive a horse with a set of skips in the main roadways. The wheelers are lads who drive a horse with one skip to and from a flat and a face.

Preparations are being made to instal the main and tail rope system of haulage.

Ventilation is induced by a Waddle fan 43 feet in diameter, revolving 35 times per minute, causing one-inch water-

gauge pressure, but capable of going 60 revolutions per minute. The driving engine was manufactured by the Waddle Patent Fan and Engineering Company, of Llanelly, Wales, and is a compound tandem, direct acting. The emergency engine, which is placed in line with the main engine, but on the other side of the fan, only has one cylinder. As the fan must revolve in the same direction all the time, when the emergency engine is coupled up to it, the connecting rod works under and over, instead of over and under. The result is that the upper guide bars become hot, owing to the greater friction of the guide blocks attached to the crossheads when worked that way. Waddle's fan is known as an open running

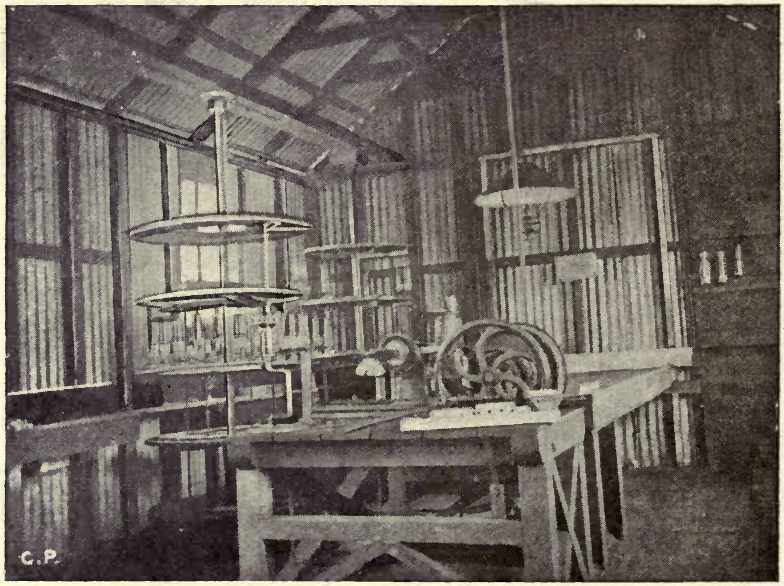

Fig. 201.—Lamp Cabin.

fan; that is, it is open to the atmosphere all round the circumference. The blades and casing all revolving together. The air is taken into the fan on one side only, and on that side the casing is widened out. The blades, which are inclined backwards, are alternately long and short. The long blades reach the centre, and so as to give the maximum area for the entrance of the air, they are increased in width as they near the centre. On account of the large diameter, a high perpheral speed is obtained with a comparatively small number of revolutions. As seen in Fig. 200, the fan is narrow,

but there is no occasion to have it wide, since the air can escape all round its circumference. The trumpet-shaped outlet extending beyond the ends of the blade increases the efficiency of the fan, since less power is required to discharge the air, for the area of the outlet being greater than that at the tips of the blades, the velocity of discharge is gradually reduced, and resistance varies with the square of the velocity. It is better not to have a bearing on the intake side of the fan, as it stops the free inlet of air. A Waddle fan can be worked at a greater rate than a Walker fan, as the latter, if driven too fast, would shake about and wear out the bearings. There are two loose doors on the top of the air shaft, which

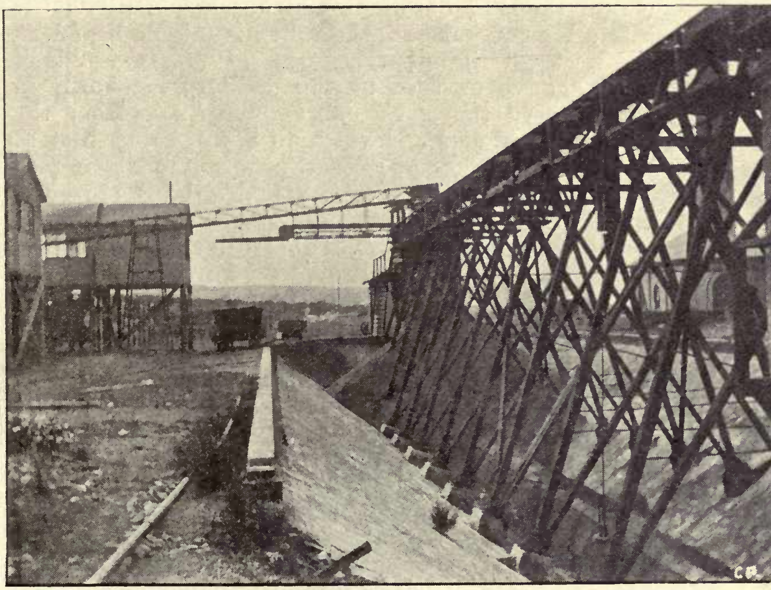

Fig. 202.—Jeffrey Conveyor.

act as a safeguard in case of an explosion, in addition to the windows, which would naturally break. A large grating is placed in front of the fan in the fan drift.

Cambrian safety lamps, an improvement on the Evan Thomas lamp, are used at this colliery. The lamp cabin, with the necessary appliances for cleaning, filling and locking the lamp is shown in Fig. 201. When ready for use the lamps are placed on four decker turn tables. The upper portion of each lamp is suspended from a numbered hook above its corresponding oil vessel, so that the wick can be readily lighted

before required by the men, and the flames will warm the glass. The illuminant used is a mixture of colsa and kerosene oils. The lamps are locked with the usual leaden rivet, a dozen of these being cast at a time in one mould. Formerly they tried Stoke's alcohol lamp when testing for gas in the mine, but now they use hydrogen with a Hebblewhite Grey lamp.

The coal is tipped on to two shaking screens with a billy-fair-play below to weigh the slack. The round coal falls on to a steel picking table, where the "chidder"—slate and brasses—is picked out and the balance weighed on a Pooley machine. As each skip is tipped on to the screen, its token is taken off and slid down a wire to a lad who places it on the picking belt near the heap of coal to which it belongs. As the coals falls into a hopper waggon, the token is taken off and its number noted by the weighman.

The Jeffrey conveyor used at this colliery is shown in Fig. 202. It is used for slack only. The slack from the screens is raised by a bucket elevator to a travelling belt of steel that carries it to a shoot which directs it into a waggon, but when there are no waggons, or if it is desired to store the slack, the mouth of the shoot is closed, the slack fills it up, and then the buckets of the conveyor that circulate round the framework (to be seen crossing the picture in the near distance) are able to reach the coal and convey it to the top of a tower from which it is fed on to another conveyor at right angles to it. This conveyor travels towards a second tower, partly shown in the foreground. There are several slide valves in the bottom of the trough along which the buckets travel; by pulling out the proper one, slack is made to fall in any part of the open storage hopper desired. This hopper is excavated in the ground, and is V-shaped, and lined with bricks. At its bottom a tunnel runs for its full length, large enough for men to walk along in it. There are doors in this tunnel which can be opened from the inside, so when it is wanted to load the slack stored in the hopper, a door of the tunnel is opened and the buckets scrape the slack along till it reaches the far tower, when it is lifted up to be eventually emptied on to a short conveyor with a shoot at the end, which is lowered over the waggon to be filled. The capacity of this plant is 100 tons of slack per hour, loaded into waggons from the storage. The buckets are triangular in cross-section, for they have to act as scrapers when in a horizontal position, and as vessels when in a vertical position. The buckets are fastened to two strands of a roller chain. The hopper is given an inclination lengthways to assist any rain-water to flow towards the end, where a pump raises it to the surface.

Burwood Extended.

This colliery suspended operations for many years, but is now at work again, under the management of Mr. G. F. Thomas. There are two seams, both of which have been worked to a certain extent. The upper seam, 230ft. from the surface, is the Victoria Tunnel or Burwood seam, which is the most extensively worked of the two; while 269ft. deeper is the Borehole seam, containing 4ft. 10in. of workable coal. The upper seam consists of 2ft. 9in. to 3ft. of inferior coal and clay, which makes a good roof; then comes the top coal, which consists of 2ft. 6in. to 2ft. 7in. workable coal, followed by a 2in. clay band. This is succeeded by a band of coal used in the colliery boiler, and which is supplied at the rate of one ton per month to each man employed at the colliery for household purposes. There is then another 2in. clay band, a band of splint, and finally the lower workable coal, 2ft. 3in. thick.

The coal from this colliery is unscreened, and is mostly used as a bunker coal, being good for steaming purposes.

They use three Jeffrey's electric chain coal cutting machines, size 17A. They are fixed on their self propelling trolleys, so as to make them high enough to cut into the bottom of the splint coal. These are called six feet machines, but it is considered good holing if they cut in five feet six inches with a four inch kerf. The points are fixed in the sockets of the chain with set screws, so that they project $1\frac{1}{4}$in. They are set so as to make a clearance top and bottom as well as in the centre. As the machine works, it rakes out all the fine cuttings made. Fair work for one machine in an eight hours' shift is to hole three 8-yard bords and one narrow place, e.g., a 4-yard heading. The self-propelling truck consists of an iron frame mounted on axles fitted with wheels. At the rear end of the frame is shafting, resting in suitable bearings. This shafting is driven by means of a chain and sprocket wheels by the machine motor, and transmits motion to the axles of the truck. The machine motor can be thrown in or out of gear by means of a clutch, and when propelling the truck, the cutting part of the machine is put out of action. The motor is further equipped with a reversing switch, so can cause the truck to travel backwards or forwards. The coal above the cut, as far as the bottom of the top coal, breaks away easily with long handle picks and bars. Then the top coal is shot down with bobinite, and when cleaned away, the bottom coal is lifted with shots.

The cages run on rope guides in the 20ft. diameter shaft. Angle irons are arranged at the mouth of the pit, so as to engage the corners of the cage and steady it when at rest. The

hoist is a duplex direct acting steam engine, with poppet valves, made by Grant, Ritchie and Co., of Kilmarnock, in 1889. The drums are cylindro-conical, with the brake path between; only the conical portion of the drums is used. The driver stands on an elevated platform to work the engine. There are five Cornish boilers.

The engine used for driving the electric generator is a McEwans type, manufactured by the Jeffrey Manufacturing Company. It has a 16in. cylinder and 16in. stroke, and is provided with a patent fly-wheel governor. It is connected

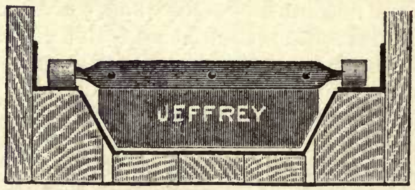

Fig. 203.—Trough and Scraper.

with the electric generator by means of leather belting. The generator is 100k.w. continuous current, run at 500 r.p.m. It has 275 volts, and 365 amp., with full load. It can slide on its bed plate, so as to adjust the distance to suit the length of the belt.

The Jeffrey conveyor at the Burwood Extended being intended to fill unscreened coal into a 1200 T. wooden hopper, which is emptied through horizontal sliding gates into waggons below, consists of a series of scrapers, not buckets, which

Fig. 204.—"Alabama" Type.

pass along a steel trough (Fig. 203), and drags the coal, large and small, along with them, as far as the valve which is opened over the spot where it is desired to deposit it. The scrapers are attached at either end to a steel roller chain of the "Alabama" type. (Fig. 204.) The steel trough, which is supported on a wooden structure, is placed below the lower part of the roller chain, the scrapers or "flights" returning overhead. The valves in the trough are about 11ft. apart, and are worked by a rachet and pinion.

The Guibal fan is 35ft. in diameter and 10ft. wide; the tips of the vanes curve slightly like a scoop. The fan—the casing of which can be seen in Fig. 205—runs at 33 revolutions per minute, and supplies 99,000 cub. feet air per minute. The fan engine was made by the Grange Iron Company Limited, of Durham, England, and is supplied with variable expansion.

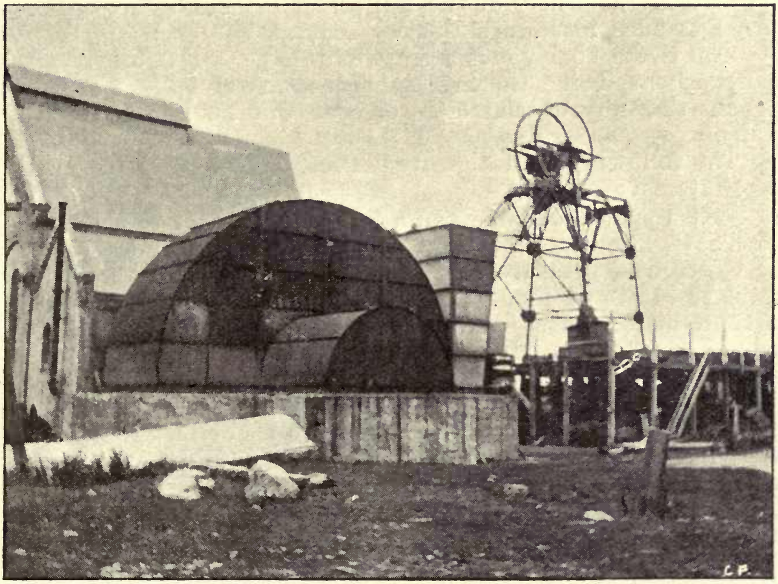

Fig. 205—Pithead Frame and Fan.

The mine timber is classified according to their lengths, and are stacked at the surface between posts on which are marked their lengths, so there is no time wasted in sorting out the length of prop desired when wanted for use.

The Maitland Field.

The Greta seam, which is the next largest producer of coal to the Borehole seam in the Northern coalfield, was first located in the Cessnock to Homeville part of the Maitland district, near where the Abermain colliery surface works are now situated, by a geological survey party under Prof. David, in 1886. Now, this is perhaps the most important of our coalfields, and contains the thickest known seam in New South Wales, from 14ft. to 34ft. thick. This discovery resulted in a large area of land being reserved in the interests of coal min-

ing. There are two seams worked in the Greta coal measures. The top seam is split in places. The East Greta colliery works the bottom Greta seam. The Heddon Greta colliery works the top or main Greta seam. At Stanford Merthyr they work the lower split of the top seam, which splits up again deeper down. The Pelaw Main colliery works the middle and the bottom of the top seam. At Hebburn they work both the upper and lower split of the top seam. Abermain works the whole of the top seam. Aberdare and Aberdare Extended also work the top seam.

The Greta coal yields from 40 to 42 per cent. of volatile hydrocarbons, being the highest proportion of volatile hydrocarbons that any of that class of coal contains in New South Wales.

The following quotation from Prof. T. W. E. David* will be of interest:—

"At a spot about one and a half mile further to the east-north-east, known as the 'Pinch,' there is a natural outcrop of the Greta coal measures on the north-west side of the Wollombi to Maitland road. In this neighbourhood, traces of a vast pre-historic fire in the Greta Coal Measures are to be noticed at intervals. It has extended beyond the 'Pinch' in a westerly direction, and in a north-easterly direction it has spread through Cessnock along the outcrop to Pelaw Main and Stanford Merthyr. It originated probably not far from Cessnock, in the 'brassy top.' Then it spread south-westerly and north-easterly along the main seam. Between Abermain and Hebburn, where the seam splits, it followed the lower, that is, the main or middle seam, and kept along it to Pelaw Main and Stanford Merthyr, near which the fire seems to have died out. The fact that these splendid seams have been on fire in prehistoric time, on a very large scale, is one which I should like to impress very strongly on the proprietors and managers of the collieries in this important coalfield. There can be little doubt, in my opinion, that the fire, which has extended over a total distance of fully fifteen miles, along the outcrop, resulted from spontaneous combustion. So intense has been the heat of this great fire that, as already mentioned in an earlier description of the sections in this locality, large areas of sandstone and shale have been actually smelted by the great heat, and a rock has resulted closely resembling a volcanic lava, such as andesite or basalt; in fact, it was originally mapped by me as volcanic ash and scoriae. . . . But the evidence is of much wider significance, as a warning to colliery mana-

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*The Geology of the Hunter River Coal Measures, New South Wales. By authority, 1907, p.144, et seq.

gers and owners, of the great risk they run if they neglect to take all possible precautions against outbreaks of fire through spontaneous combustion in this part of the field. The fact may once more be emphasised, that it is absolutely necessary, in the interests of the safety of the collieries and those working in them, that the whole of the 'brassy tops' should either be taken out of the mine to the surface when the seam containing them is being worked, or, if any be left underground, the areas where they stand should be securely walled off from the rest of the workings. The former method of guarding against risk from fire would be preferable to the latter.

"I would specially here emphasise the danger of working the lower seam of coal in such a way as to permit the overlying strata to collapse, and so produce cracks which admit air to the overlying seam containing the 'brassy tops.' In this case, there is a danger of spontaneous fire breaking out in the 'brassy tops' of the upper seam—a fire which may easily spread downwards through the cracks and crevices of the broken rock into the main seam. Something of this kind has already actually happened in the East Greta Mine (in 1903), but, thanks to the energetic action taken by Mr. Azariah Thomas, the manager, the portions of the lower seam, to which the fire was communicated at that mine, through what was probably spontaneous combustion in the upper seam, have now been all safely and securely walled off.

"A fire due to spontaneous combustion has also occurred at the Heddon Greta Mine in this end of the Greta coalfield (June, 1905), and the districts affected of the mine have been walled off.

"At Stanford Merthyr also slight heating has been observed in refuse mine material in the neighbourhood of a fault. It should be stated, however, that there is no evidence to connect the recent fire (29th October, 1905) at Stanford Merthyr Colliery with spontaneous combustion. On the other hand, there is a probability that the fires, both at the Old Greta Colliery and at the Anvil Creek Colliery, were the result of spontaneous combustion."

Mr. A. A. Atkinson, the Chief Inspector of Coal Mines, draws attention to the following points:—*

(1) The advisableness of laying out the workings in such a way that, in the event of a fire, small districts may be sealed off, instead of having to close the whole of the colliery.

(2) The necessity for the removal of all small coal, unnecessary timber, and any other easily inflammable material, from the workings.

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*Ann. Rept. Dept. Mines, N.S.W. for 1903, p. 101, and 1905, p. 113.

(3) The practice of building stoppings with small coal, or other carbonaceous material, and timber is one which should be discontinued entirely. These stoppings are usually put in several feet thick, and this is conducive to heating. Such a condition may eventually give rise to a fire, the result of spontaneous combustion.

(4) Arrangements, where practicable, for an adequate supply of water, under pressure, in order to deal with an outbreak of fire.

(5) The necessity of regarding all the seams in the Greta Measures of the South Maitland Coalfields as being liable to spontaneous combustion.

(6) The necessity of inspecting old workings.

Mr. V. D. Lewes determined the ignition points of various kinds of coal as follows:—Cannel coal, 370 degrees C.; Hartleport coal, 408 degrees C.; Lignite, 450 degrees C.; Welsh steam coal, 477 degrees C. Prof. David, commenting on this writes:—*

"Now, as the Greta coal is essentially in places of a cannelly nature, passing here and there into true cannel, its low ignition point would in itself render it liable to spontaneous combustion. In the second place, comment has already been made on the fact that the Greta seams, of all the coal seams of New South Wales, are the most liable to 'perishing' towards the outcrop. This is so marked that a thirty-foot thick Greta seam is usually so perished at its actual outcrop as to show a thickness of only an inch or two of earthy carbonaceous material to represent the whole seam. The remainder has been removed by weathering—that is, by oxidation. Neither the Tomago nor the Newcastle coal seams perish towards their outcrops to the same extent as do the Greta seams. The Greta seams are specially liable to oxidation, and even in cases where the 'brassy tops' are not present, every precaution against risks from spontaneous combustion should be taken by mine managers."

Greta Colliery.

This colliery is famous for its numerous fires. It is now abandoned, and the machinery taken away. The downcast shaft and tunnel are sealed, grass is growing on the stopping of the former, and the observation pipes are plugged with wood. The waste heaps, mostly composed of material filled out during the various fires, are still burning, and it is not safe to walk on them for fear of sinking down into the hot

*Op. Cit., p. 148.

ashes. The gob stink, the smell of a newly lighted coal fire, once experienced never to be forgotten, is noticeable in the neighbourhood of these heaps.

This colliery was worked for 20 years. There are two seams, 14ft. apart, but only the No. 1 or top seam was worked. This was extracted in two sections, and was made up as follows:—

Coal, brassy tops ..	1ft. 3in.	
Band	0ft. 1in.	
Coal	1ft. 0in.	
Band	0ft. 1in.	
Coal	3ft. 0in.	5ft. 5in. second working.
Indurated clay band thickly studded with plant impressions locally termed "white stone"	0ft. 6in.	
Coal	4ft. 0in.	
Blackstone band ..	0ft. 6in.	
Coal	4ft. 0in.	9ft. 0in. first working.
		14ft. 5in.

The top seam varies considerably in thickness, but may be taken to average 14ft. 6in., the bottom seam being 3ft. 7in. thick. The roof consists of a band of coarse conglomerate immediately above the "brassy tops" for a few inches in thickness, followed by extremely soft sandstone, which decomposes into firm sand on exposure to the atmosphere. Mr. Jeffries, the late mine manager, thinks this has much to do with the gob fires, for, falling as it does, immediately after the "brassy tops," it acts as a covering or blanket, and being a bad conductor of heat, when chemical action occurs, the heat cannot rise to the surface to be cooled by the ventilating current, so the temperature gradually increases till the ignition point is reached. "Brassy tops" are shales containing marcasite, the latter decomposing into sulphate of iron, which weathers white. "Brasses" also occur in the coal in places, more especially when the coal is broken up. It does not occur in nodules, but is generally found in streaks predominating along certain bedding planes. It is not continuous, showing preference for the brittle black bituminous portion of coal. It also occurs in vertical joints of the coal, so was evidently precipitated after the coal was formed, not simultaneously with it. Finely pulverised bituminous coals in contact with air begin to oxidise between 120 and 155 degrees C. The ignition tem-

perature is about 330 degrees C. Coal naturally absorbs oxygen from the air, and undergoes a process of slow combustion. Marcasite, when decomposing, swells, breaks up the coal, and thus exposes a large surface to oxidation. A gob fire starts gradually; first there is an increase in temperature, followed by an unmistakable smell of gob stink owing to the volatile matter being distilled off, and a mist is formed.

The downcast shaft is 15ft. in diameter and 420ft. deep, and about half a mile distant is the upcast, which is rectangular in section, 10ft. by 5½ft., and 201ft. deep. There is also a tunnel entrance 36 chains from the downcast shaft, which was used as a travelling way for men and horses.

The coal was extracted on the bord and pillar system. The bords averaged 24ft. wide, while the pillars varied from 12ft. to 45ft. Cut-throughs connected the bords every 105ft. The first working was carried forward in the lower or 9ft. section of the top seam, until the cut-through was connected, when they worked the top section back in the reverse direction. The "brassy tops" were left standing, but they eventually fall, sooner or later, for want of support. Fire damp had been occasionally found in very small quantities, but it had been detected rising from the heated debris.

There have been eight fires in this mine altogether; seven due to spontaneous combustion, and one to a naked light. For information concerning these fires I am largely indebted to Mr. J. Jeffries, who was formerly in charge of this colliery, and has given an account of it in his paper entitled "The Occurrence of Underground Fires at the Greta Colliery, New South Wales." (Trans. Inst. Min. Eng., 1904-05, XXIX, p. 518). The first fire occurred in 1897, at a point where water dripped from the roof on the fallen "brassy tops," which accelerated chemical action. Having been observed while in the incipient stage, it was easily filled out. A few months after the second fire, a creep occurred, resulting in the loss of a district. Large volumes of water held in the strata were liberated, and as the pumping machinery was not sufficient to keep the water down, it was turned into the dip working. The creep cut off the ventilation from the greater portion of the affected area, and as was also the case with subsequent fires, direct attack was too slow to be effective, so it was attempted to isolate the area by building stoppings. These were built of brick, or brick and clay, also of timber and loamy sand, when the crushed condition of the pillars made a tight joint with brickwork impossible.

Mr. Jeffries writes that, "The experience gained in dealing with these underground fires emphasises the difficulty of coping with such evils by the sealing off process, and also the

advisability of using every endeavour to overcome them by direct attack, and the removal of the heated material to the surface; for, unless the stoppings are limited in number, small in sectional area, and the pillars crushed, absolute extinction of the heated material cannot reasonably be expected."

A fire broke out on 5th December, 1900, resulting in the loss of five lives. The district north and west of the downcast shaft had been largely worked, and were practically abandoned; also a large area east and south of the main south level had been worked. Of previous fires, six had occurred south of the big jig, and one on the north side of the downcast shaft; the last, being due to a workman's carelessness, was not a true gob fire. The pit was sealed down on the 10th December, 1900, and re-opened in April, 1901, but after eleven days the fresh air caused another outbreak. The fire caused heavy falls of the roof. The action of the flames could be traced on the coal over the same area as the falls, i.e., over a distance of 825 yards.

The best way to attack an underground fire, when possible, is to fill it out. Sealing off is unsatisfactory, partly on account of the slowness with which heat is conducted away through the strata above and below, and partly on account of the difficulty in shutting off the air. Experiments carried out by Dr. J. S. Haldane and Mr. Meachan* showed that air might be so bad as to extinguish a lamp, and yet be nearly as effective as pure air in producing heat by slow oxidation. Air containing 17 per cent. of of oxygen will extinguish a lamp, but the oxygen would have to be reduced to less than one per cent. in order to really check heating.

The sealing of the Greta colliery was carried out as follows:—

Bunton holes were cut in the solid rock of the shaft, 19ft. from the surface. Hardwood buntons, 12in. deep by 5in. wide, were put in, across which hardwood planks 2in. thick were laid. These planks were cut to the circle of the shaft, and covered with several layers of brattice cloth. Above this was placed 4ft. in depth of plastic clay, and the whole was covered with water for a depth of two feet. In the centre of the scaffold was a rectangular door with an eye bolt at each corner, to which chains were attached. A wire rope connected the chains to a windlass, which was used for lowering and raising the door. The sealings were completed as far as possible, with the exception of the doors, and these were lowered into position simultaneously. A wrought iron pipe, one inch in

*Trans. Inst. Min. Eng., 1898, XVI., 457.

diameter, was carried for six feet below and through the sealings to the surface, for observation purposes.

The opening at the tunnel was sealed with two brick stoppings nine inches thick, between which eight feet of sand was placed and well rammed in. The roof, side and floor were cut to a solid foundation, to allow a tight joint to be made with the brickwork. There was no door in the tunnel stopping. The stopping was not built too strong, as it was to be pulled down again at a later stage.

After some months, the sealings were removed, and the heated material filled out, but it had to be cooled first with water. The sides of the pillars were found to be incandescent to a depth of four feet, so an iron bar was driven into the pillars for this depth, and the nozzle of a hose inserted. This method of cooling proved very effective. Where large pieces of "brassy tops" had been under water for weeks, and the water subsequently drawn off, it immediately commenced to heat, some of it actually breaking into flame. This proves that a temporary flooding of the mine was no good. If unsealed too soon, though the flame may have been suppressed, and the external portion of the heated matter cooled down, the internal parts of the mass still remain heated, and only await the necessary supply of oxygen for active combustion to develop again. The process of cooling is very slow under non-conductive material such as sandstone and conglomerate. The occurrence of large falls of roof brought about a state of affairs favourable to spontaneous fires, as these falls covered up the brassy tops and placed them outside the action of ventilation currents, while at the same time there is sufficient oxygen present to cause oxidation of the pyrites. Since the conglomerate falls in large pieces, it adds to the trouble of filling out the "brassy tops," for it has to be broken up smaller before it can be handled. Mr. Jeffries further remarks* that, "Careful observation points to the fact that when the 'brassy tops' remain uncovered by falls of stone or by the fine sand already referred to, no trouble is experienced; but in cases where blanketing or covering occurs with substances of low conductivity, trouble will almost certainly occur."

Jeffries recommends working the seam in panels, forming the pillars where permissible to the rise and dip of the seam. Also to work the pillars and brassy tops together; and when once the pillars are attacked, to extract them as quickly as possible.

Irregular work due to labour trouble would be liable to cause great loss in working such a seam, not only to the col-

*Op. Cit., p. 532.

liery owners, but also to the country, and might result in the permanent closing down of a mine if a fire started when there were not sufficient men to keep it under control.

East Greta Colliery

This colliery, which is the pioneer of the district, and is about 18 years old, belongs to the East Greta Coal Mining Company Ltd., who also own the Stanford Merthyr Colliery. It is under the management of Mr. J. H. Rees, who formerly acted as under manager.

The seam being worked is the lower seam of the Greta coal measures, which about here is from 12 to 13 feet thick, the whole of it being worked, but in two operations.

The tunnels follow the seam from the outcrop, and are consequently fairly steep. No. 2 tunnel has an inclination varying between 40 and 44 degrees, and is the full height of the seam, so as to give sufficient head room. It is 2200 feet deep on the slope. Levels are driven right and left every 160 yards on the incline, and are connected at the back or in front of the shaft by undercasts or overcasts, according to circumstances, which are really horizontal passages along which skips can pass the shaft.

The mine is divided into pannels, and as each pannel is worked out it is sealed off.

The method of working is by bord and pillar. Near the surface the bords are 8 yards wide, and the pillars are 8 yards wide also; deeper down the pillars have to be stronger, so are made 10 to 14 or 15 feet wide.

A jig or self-acting incline is sunk between two levels. They are driven down hill rather than up, as being safer, and easier to ventilate. A 15 yard pillar is left on each side of a jig. Through this each bord is driven, commencing with narrow work, and then opening out to the full width of eight yards. The bord is taken out for a height of 7 or 8 feet, that being convenient for timbering. At every 50 yards a cut-through, 4ft. by 4ft., connects adjoining bords for ventilation purposes, but these cut-throughs are not made continuous through all the bords, it being found that ventilation in the bords is facilitated by staggering them. These cut-throughs have steps cut in them, or ladders, according to their steepness, for men to travel on. A bord is carried on where possible to the limit of 20 chains, this distance being adopted as over that the wheelers have to receive increased pay for transporting the coal. At 20 chains the bord is driven narrow again, and adjoining bords are connected by cut-throughs, 4ft. by 4ft., in a continuous line; this is later on enlarged to 9ft.

wide by 7ft. high, and timbered, thus forming another jig. This enlarging of the end cut-throughs is termed stripping the jig, and is done by two men, one working on either side. A shoot is placed at the bottom of this jig, and the coal allowed to roll down by gravity, but when the stripping is completed, rails are laid, and a place prepared at the top for the brake drums.

When the bords in a section have been driven, men commence to drop the pillars and top coal. The pillar immediately below the upper level is left as a support, but the top coal of the first bord is dropped. Then, commencing a chain from the jig instead of 15 yards, so as to protect the jig, the pillar is taken out in four foot strips from the bord below, for a height of seven feet. When eight yards have been worked, several of the props of the first strip and the continuation of them in the bord are drawn, only just sufficient being left to temporarily support the roof. The roof is then shot down by placing blasting powder in holes made nearly vertically overhead. After the first step has been worked, there is always a free end to shoot against. A shot in the lowest portion of the strip often fetches down the lot, but if it does not, more than one hole has to be bored. If the roof is rotten, then the powder is tied on to the timber, and the prop blown down, or the prop may be rammed down by a long pole. It is intended to always keep three rows of props at least between the second working and the working face of the pillar, but sometimes the shooting may fetch down the roof up to the face, in which case one has to start on the pillar as if commencing afresh. The coal won from the pillars slides down to the track in the bord, when it is filled into skips. As the roof will not allow the full width of a pillar to be extracted, a rib is left, when signs of weakness occur, but this is sometimes fetched down when dropping the roof. The stone overhead is conglomerate, and generally stands well, but sometimes falls with the top coal. If much of the roof falls, they do not bother to sort out the coal, but leave it where it falls. The bords are worked forward, and the face at the top is in advance of the bottom, as this gives a better grade for the miners to reach their work. The men arrange a stand by placing a plank under and over two adjacent and parallel props, the projecting end serving as a support to stand or sit on (Fig. 206). If the coal of a pillar shows signs of being tender, it is held by slabs resting against props placed close to the pillar, and so as to prevent the posts from falling, long sticks known as "needle timber" are placed so that one end rests against the foot of a prop and the other is let into a hitch in the roof, so arranged that it is a little higher than the end resting against the prop. The pillars

are worked backwards. Several pillars may be worked at the same time, but the upper pillar is kept half a chain in advance of that next below it. The coal is not undercut, as it is found to be inconvenient to fix sprays, on account of the steep inclination, but it is shot down in the solid. This is, of course, more expensive in explosives, but the men get a larger out-

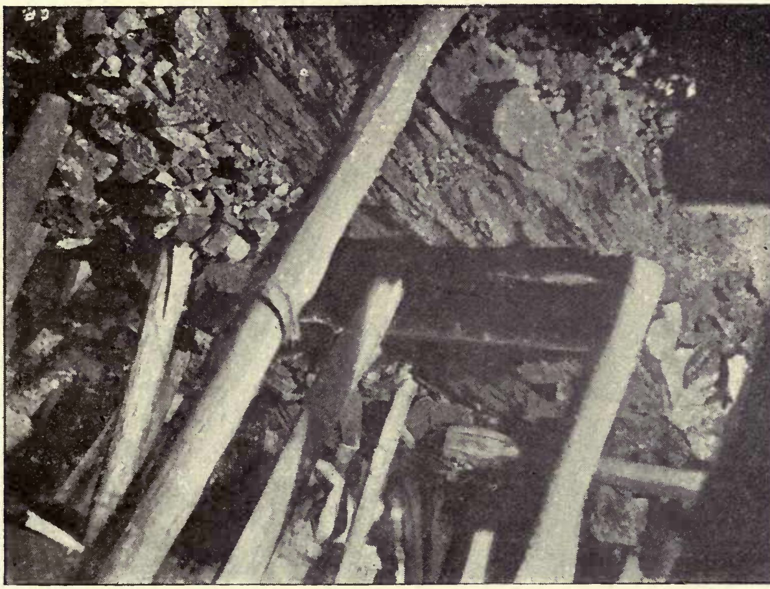


Fig. 206.—Pillar Work.

put in a given time, so they find they earn more in the long run, besides there is less slack made.

All the transport of coal in the bords is done by hand, that in the jigs by gravity, in the levels by horses which are raised and lowered every day, and in the tunnels by steam. The jigs between levels have four feet gauge rails for the cage, and parallel with them 2ft. 2in. gauge rails for the dummy, which is a small, narrow waggon filled with old iron to a little more than counterbalance the cage, empty skips and rope, so as to fetch them to the top of the incline. Near the entrance to each bord a small chamber is cut out called a "coup over." This is a place into which an empty skip can be upset off the rails so as to make room for a full one, as only a single line is laid in each bord. The jigs vary in angle according to the dip of the seam, consequently the cages have

to be made accordingly, and they have a label on them according to the degree of angle they are made to suit. These jig cages (Fig. 207) are horizontal platforms to carry one skip at a time, mounted on a wedge-shaped under carriage properly braced. The skips are kept on the platform by a finger catch. A wooden chock is bolted to a sleeper a little way back from the entrance to a bord, which, when placed across the rail nearest to it, rests against another bolt, and thus blocks a

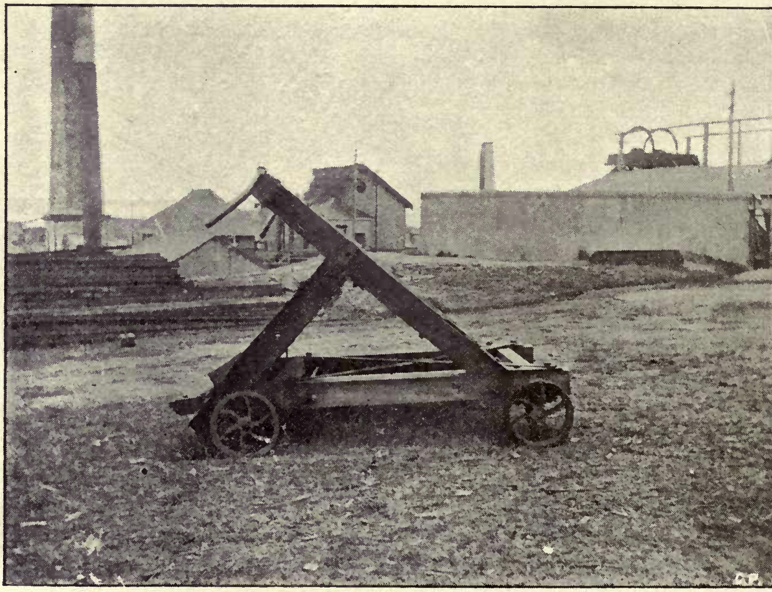


Fig. 207.—Jig Cage.

skip from running unchecked into the jig. This chock must always be left in position, as accidents, sometimes of a fatal nature, have been caused by neglecting to do so. If the chock is found out of place, the man in charge is fined or prosecuted.

In the levels, alternate sleepers are made long, so that they reach right across the gutter; this is because the water softens the coal, and the weight of the skips passing over the rails, if supported entirely by short sleepers, would spread the coal out.

When running skips on to platform cages at the lower levels, as there are no chairs to support the cages, there is a certain amount of spring in the rope to be taken into considera-

tion, which causes the cage to be in a different position when partly loaded to what it is when empty. To allow for this difference, a sheet of iron is used at the flat, so that a skip can be pushed sideways before running it on to the cage. There is no necessity to have such sheets at the upper levels, as there is not so much spring in the shorter length of rope. The downhill side of the level near a flat is a little lower than the uphill side, so as to compensate for the inclination of the angle.

The levels are so arranged that any water gravitates towards the tunnels, from which it is at present bailed, but will shortly be raised by pumps. When sinking for another lift, the water is dammed back in a portion of the lowest level, and the tunnel continued in its proper direction, but a twelve foot pillar is left between the bottom of the former lift and the commencement of the new, which is finally broken through when the new lift is completed. An electric winch is employed for hoisting while sinking the new lift.

A new electric plant has been installed, which consists of two three-throw Worthington pumps of the horizontal pressure pattern, with pot valves. These raise 145 gallons per minute in two lifts, each of 700ft. The upper pump is 6in. by 12in., and the lower 6in. by 9in. These pumps are driven by belt from a dynamo. The motor has 710 r.p.m., which is reduced to 41 r.p.m. at the pump.

The main winding engine was made by R. and J. Morison and Bearby, of Newcastle; it is a duplex 22in. cylinder, with a 4ft. 6in. stroke. There is one 7ft. drum divided in the middle by a brake path. The enginedriver has two electric pushes worked by his feet, so that he can signal to the men working at the tunnel both on the surface and underground.

A British-Westinghouse direct current generator compound wound, of 12.5k.w., 250 volts, with 400 r.p.m., is used for electric lighting and for driving an electric winch.

The main tunnel is 10ft. 6in. high, 12ft. wide on top, and 13ft. wide at the sill inside timbers. It is supported by full sets of round ironbark timber, not less than 8in. diameter, placed 4ft. apart, and closely slabbed at the back and sides with ironbark slabs 2in. thick. The legs are shouldered and morticed into both cap anl sill, while the cap and sill have 15in. horns let into hitches in the sides, so as to keep them from falling down hill. There are no distance pieces between the sets. When additional sets are used for further support, they do not have horns. At flats where levels branch off and legs have to be omitted, the cap-pieces are picked up by stringers, which rest on legs placed out of the way of the opening. There are two lines of rails. These are not fastened to special sleepers, as they would be shifted by the swelling of the bottom,

but are dogspiked to the sides of the sets. There is no occasion to allow spaces between the rails for expansion and contraction, as the temperature is fairly uniform throughout the year. The rails are connected with fish-plates, and occasional rails have holes in their flanges, through which they are spiked to the sills and thus prevented from working bodily downwards. The tunnel cage is a double decker (Fig. 208); the top deck is covered in on top and at ends, and is used for men and horses, as well as for skips. When horses are on board, wooden sides are put on. Two skips are on each deck, placed side by side, and kept in position by both axle catches and finger bars. When

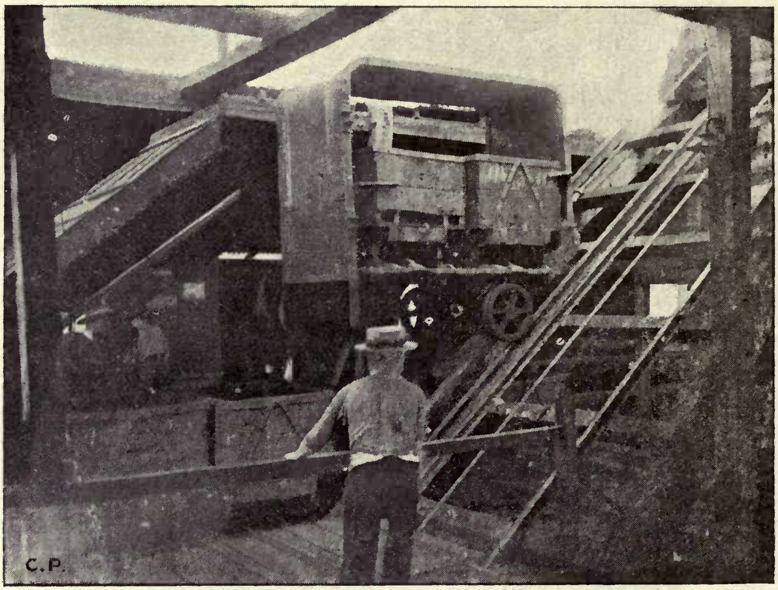


Fig. 208.—Double-deck Tunnel Cage.

skips are to be run off the cage, the finger bars are thrown on one side and the axle catches propped up. The skips are run in at the side of the cage on to angle iron rails. As all the uncaging takes place at one spot, when the full skips have been run off the upper deck, and the empty skips run on, the enginedriver has to raise the lower deck into position. Under the lower deck is a water tank. This is emptied automatically by a fixed finger that strikes the lever attached to the valve of the tank. The wheels of the cages have double flanges, so as to help them keep the rails. Ten men travel in the covered

cage at a time. The upper and lower decks are linked together, such a joint preventing accidents, which used to happen with stiff frames where the grade of the tunnel varies. The mouth of the tunnel is protected by bars pivoted and counterbalanced so that they can be easily raised. There is also a horizontal door working on a hinge, one for each half of the tunnel. These are so connected together with chains passing over pulleys that when one is open the other is closed. The banksman raises the door over the up-coming cage, and when it reaches the surface the empty skips run on rails, fastened to the top of the closed doors, into the cage. (Fig. 209.)

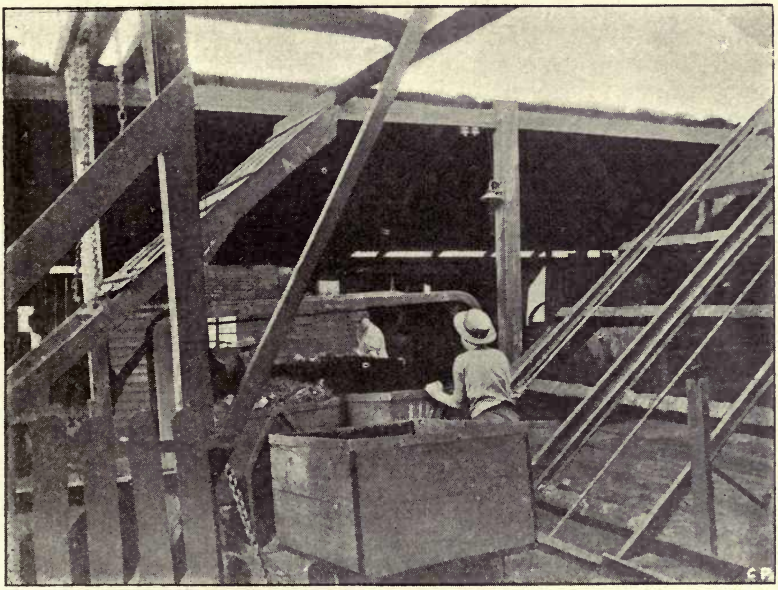


Fig. 209.—Unloading Top Deck of Cage.

A second tunnel, known as the steam jig, is 7ft. by 7ft., and only has one pair of rails. Two ropes pass down it, which are wound up on two different engines. One is led down the side of the tunnel and winds from No. 5 level to No. 4 level, while the other winds from No. 4 level to the surface, and is worked from a 5ft. drum, the engine being geared from 21 to 100.

The tunnels and jigs are sunk with self-tipping tanks known as "alligators." The bail to which the capping of the rope is attached is fastened to the tank at a point below the

centre of gravity, and the back wheels have a larger tread than the front wheels. By having the rails horizontal at the surface, and extra outer rails continued on the incline, the forward wheels keep to the inner rails, while the back wheels run on the outer rails, thus raising the bottom of the tank and emptying its contents. When men are raised or lowered in this tank, a chain is made to connect the bail with the lower side of the alligator, so that there shall be no fear of it shifting and precipitating the men. The alligators for jig sinking are smaller than those for tunnel sinking, while those for sinking small airways are smaller still, and do not run on rails, but have runners attached like a sledge, and slide on the coal.

Ventilation is carried out by two 9ft. diameter Waddle fans, and a three-quarter horse-power booster fan underground, which is driven by electricity, to help the air current along. The entrance to each bord is provided with a door to regulate the air, and the cut-throughs are stopped up as fresh ones are made. The end of the bords past the last cut-through divide the intake from the return by brattice cloth, as usual. The levels not being wide enough for the use of brattices, a large galvanised iron pipe is suspended from the roof, leading from near the fan up to the first cut-through, for a distance not exceeding 50 yards.

A fire occurred in one pannel of this colliery. It was, however, not due to spontaneous combustion of coal in the lower seam, which is the one being worked, but was due to a crush taking place and admitting air through the roof to the top seam, where spontaneous combustion started.

Brick syphons are built in the lower stoppings of old workings, so as to let out the accumulating water. Carbon dioxide is found to emerge from the old bricked-in workings.

This company owns the railway line from West Maitland to Stanford Merthyr, the A. A. Co. owns the branch from Aberdare Junction to Cessnock, but the traffic is attended to by the East Greta company. The workshops at the colliery are used mostly in connection with railway work.

A briquetting plant, belonging to a separate company, is located near the East Greta colliery, but did not prove a commercial success.

Heddon Greta Colliery.

This colliery belongs to the Heddon Greta Coal Mining Company Limited, and is under the management of Mr. James Barnes.

The mine is worked from tunnels, or rather slopes, at an angle of 33 to 38 degrees, some 1600ft. long. The head gear

is, in consequence, simple, as shown in Fig. 210, since the resultant of forces comes chiefly on the vertical members.

The cage holds two skips, and has a tank for baling purposes. On account of the inclination of the shaft, winding has to take place from different levels. The main engine at No. 1 tunnel was manufactured by R. and J. Morison and Bearby, of Newcastle (N.S.W.), and has 22in diameter cylinders, with 4ft. stroke, and a single 6ft. drum divided in the centre by a brake path. The coal is worked for about 16ft. thick in two workings. Above No. 2 level the bords and pillars are each

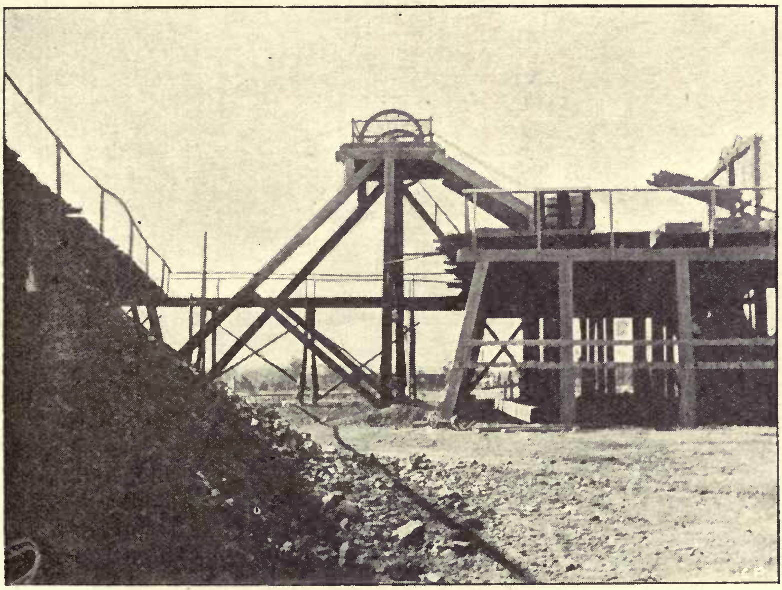


Fig. 210.—Pit Head Frame.

8 yards wide, but below No. 2 level the pillars are 20 yards wide.

The bifold safety lamp is used throughout this mine. These have two round wicks and double gauzes, but no deflector. They are made by Messrs. Abbott, Roby and Naylor, of Wigan, England.

The ventilation is carried out by means of a furnace at the surface. This is built at the foot of a stack (Fig. 211), into which the air drift leads. A brick partition divides the upcast from the products of combustion for a short distance, and then they meet higher up, to escape at the top of the

stack, the draught caused by the heated air ascending, being sufficient to draw the foul air out of the mine, so that fresh air can replace it. Underground the overcasts are cut in coal instead of in stone, as it is cheaper, besides giving some remuneration in the form of coal.

That portion of the mine which has been sealed off on account of the fire has solid brick stoppings from 9in. to 23in.

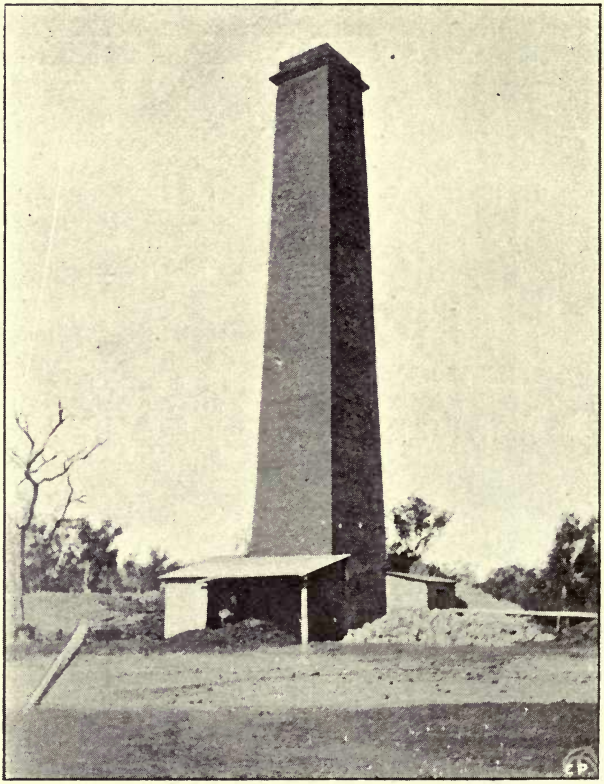


Fig. 211.—Furnace and Stack at Air Tunnel.

thick. Pipes are built into the stoppings at the highest points, so that the temperature and pressure can be taken when desired by means of thermometers and water gauges.

Stanford Merthyr Colliery.

This colliery belongs to the East Greta Coal Mining Company, and is managed by Mr. H. M. Williams. A portion of it was formerly known as the Stanford Greta mine.

The seam being worked is the bottom Greta seam; it is from 19ft. 5in. to 23ft. thick, but 220 yards from the surface it splits, the upper division being 12ft. to 15ft. thick, while the lower division is 4ft. 6in. to 6ft. thick. The split starts with dirty coal, which gradually turns into shale, and finally gives place to sandstone and conglomerate.

The upper Greta seam is found on parts of the property, but is not being worked.

The colliery is worked from tunnels. The main tunnel is an intake, and used as a haulage road by endless rope from No. 4 level to the surface. The little tunnel serves as an intake and travelling way, and in the bottom section, from the fifth to the fourth level, where the seam becomes steeper, cages are used for raising the coal. Where levels cross the tunnels, overcasts are used, as they are in the coal, which is easier to excavate than rock, and gives some return towards the cost of construction. Undercasts are used at the deeper crossings when the seam splits, as this enables the lower split to be prospected.

In the steep portion of the little tunnel, where the cage is used, the cage takes two skips, side by side, and as the long rope has a spring in it which alters the position of the cage when skips are run in and out of it, chairs were devised for the cage to rest on.

The endless rope in the main tunnel travels at the rate of 4½ miles per hour. The engine that drives it is a strongly built duplex engine, with 22in. cylinders and 3ft. 6in stroke, geared 7 to 1, which uses 100lbs. steam pressure. The skips are attached to the rope by Allan's screw clips.

Jigs are sunk in advance of the workings with electric winches, and are not constructed by stripping down cut-throughs. The seam is not so steep as at East Greta, but they use jig cages in places, though sometimes the driving track has to be made flatter at the bottom end by raising the track, so that the full cage can get a fair start. Jigs have been worked by gravity, at as low an angle as 8 degrees, and in one jig near the surface the empty cage has to be assisted up by an electric hoist, as the angle is too flat for a dummy to be effective. Boys work the brakes at the top of the jigs. Two ropes are wound round one drum, which has a brake path in the centre. The brake is a band fitted with wooden blocks.

The bords are turned off from one side of a jig, the first 12 yards being narrow work, 9ft. to 10ft. wide, then a cut-through is made parallel to the jig, connecting the bords for ventilation purposes. The bords are widened out to 8 yards. The pillars left are strong enough to stand till worked, prior

to abandoning the mine; their width varies from 8, 10, 12, and 16 yards, depending on the depth of cover. The far end of a bord does not break through to the next jig, but a pillar of coal is left. The pillars of the top section are not worked for fear of the ground caving, which might let surface waters into the workings. The mine is worked in panels, and when one panel is worked out, it is sealed off. As carbon dioxide is given off from the sealed panels, there is little chance of fire being able to burn in such an atmosphere.

The upper division of the lower seam is shot down in the solid; but the lower division, not being so hard, will be undercut. The props in the bords must have the smaller end at least 4in. in diameter. There are four such props in a row, placed 4ft. apart, centre to centre. The pillars on either side of a bord are known as the upper and lower rib respectively. A 6ft. rib is left to support the fallen roof. After dropping the top coal the roof is held up with long props, to the top of which lids are nailed. The props are tightened up from the bottom. These props serve as indicators, since they begin to speak when the pressure of the roof becomes too great to be safe.

Horses draw the skips along the levels. The empties turn off into the levels from the tunnel on the right hand side, looking down hill, while the full are clipped on to the left hand side of the endless rope. When required for any particular level, a boy unscrews a clip and sprags the wheels of the empties. On the full side of a level, the rails at the flat are level, or dip slightly towards the tunnel. Monkey chocks are placed between the rails, which hold the skips by their axles, so that they cannot run away down hill. Should a stoppage occur on the endless rope, the boy at each flat sounds a rail hanging up if he is not the cause of the stoppage, and each boy notes the delay, so that it can be accounted for and checked.

When necessary to continue sinking a tunnel, the angle is so slight that there is no occasion to build a pentice; the entrance is simply narrowed. There are six electric hoists in this mine used for sinking slants and jigs. They were made by the General Electric Company, and are 6 h.p., 22.9 amp., and 230 volts. The drum gear and bedplates were made by Morison and Bearby.

A fire and explosion took place in this colliery on Sunday, 29th October, 1905, by which six persons were killed and nine injured. The electric bells started ringing at about 1.45 a.m., but the man in charge did not suspect a fire till he saw volumes of smoke coming out of No. 1 tunnel at twenty minutes to four in the morning. The fire burst out of the main tunnel and reversed the air current, though the fan which was working

all the time sucked air in at the fan drift. An attempt was made to cut off the supply of air to the flames by blocking the "little tunnel." This was done by putting in a temporary stopping of tongued and grooved boards fixed against posts, while a brick stopping was being built. This reduced the force of the flames, but the dispelled gases made an explosive mixture which blew the stopping out and killed several men, at the same time blowing off the roof of the air drift. They then stopped the "little tunnel" and the air drift with cartloads of earth, and finally with a brick stopping. Two inch boreholes were sunk to the seat of the fire, down which water was poured. The mine was re-opened on 26th June, or 238 days later, while the colliery recommenced work on the 6th August, 1906. When at first opening up after the fire, the necessary ventilation was effected by three sets of 12in. diameter galvanised iron pipes connected with the fan, which acted as a return air way. The desire was to prevent the access of too much air, for fear of re-heating the coal. The fire coked the coal on the walls, and deposited tar on the roof in places. The timber being burnt caused the roof to cave in.

The mine is unwatered in three lifts. At present a three-throw belt driven vertical Tangye pump, 6in. by 8in., raises water from the fifth to the fourth level. A three-throw belt driven vertical Gould pump, 6in. by 8in., lifts the water from the fourth to the third level, while a geared horizontal Worthington pump, 6½in. by 8in., mounted on a trolley, raises the water from the third level to the surface. The Gould pump does very good work; each valve has a separate cover, and when a valve gets out of order it is easy to find out which it is without having to undo several bolts. Moreover, it seldom gets out of order. It is driven by a Westinghouse dynamo of 39 amp. and 240 volts. This pump has since been removed to another place, and substituted by a Worthington pump, belt driven from a General Electric Company's shunt wound, continuous current motor of 80 amp., 240 volts, rated at 22 h.p. The pump is a three-throw with 6in. diameter rams by 8in. stroke. It runs at 42 r.p.m. of the crank shaft, and delivers about 6700 gallons per hour, against a pressure of 210lbs. per square inch.

Evan Thomas' Cambrian lamps are used throughout the mine, in which they burn kerosene. The lamp room is very complete: the cleaning brushes are turned by electricity. Revolving lamp stands are placed near the window, through which they are handed to the miners, so that the lamp cleaner can reach whichever lamp is required. Each lamp is numbered and given to the same man every day, so if a lamp is damaged it is easy to trace who is responsible for it.

A 21ft. diameter Waddle fan, with a trumpet mouth, is used for ventilation purposes. It revolves 28 to 30 times per minute when the mine is idle, and 36 to 38 times when men are working. It is provided with a Harding patent indicator to record the number of revolutions the fan makes. The fan only has one bearing, and that on the outside, so there is no occasion for anyone to go into the air drift for oiling purposes, and the air has free access to the fan.

There are also six Buffalo fans driven by electricity used to help on the air current in places. These are mounted on trollies for convenience in moving about.

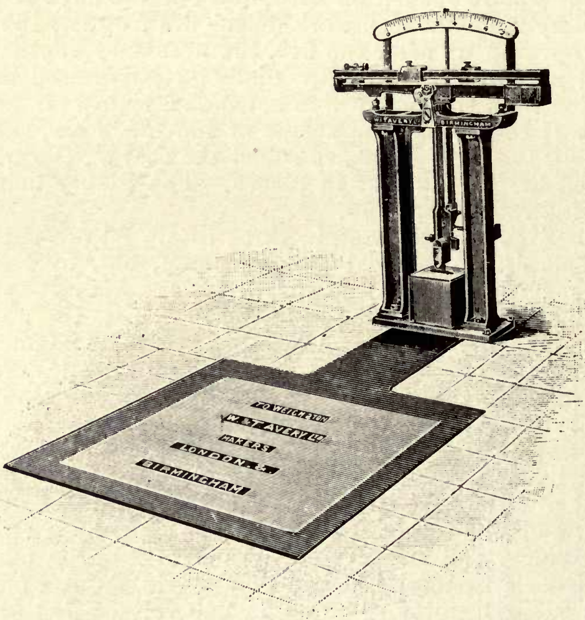


Fig. 212.—Avery Self-Indicating Colliery Weighing Machine.

The skips are weighed on Avery machines, having a capacity of 2 tons, and capable of weighing 1000 tons each per day. The platform, which is 4ft. by 3ft. 6in., has the usual system of levers placed beneath it. This machine is so designed as to be automatic and self-indicating, so there is no necessity for the weighman to handle weights, poises or levers, when once the machine is set. There is a steelyard with two graduated bars (Fig. 212), one a weigh bar graduated to 35 cwts. in 1 cwt. divisions, the other a tare bar marked by 7lb. divisions up to 10 cwt. There is also a quadrant, which has a range

from 0 to 7 cwt. in 14lb. divisions. The dashpot is filled with water, till the level of the water is just below the top of the paddle. Under no circumstances should the water be allowed to come above the paddle. One pound of washing soda should be added to the water in order to prevent corrosion of the castiron dashpot. If the pointer is found to be too long in settling, remove some of the water, and replace it with oil.

The machine is balanced while empty, and with the slides at zero, by means of the balance ball. All the skips must be brought to a uniform tare so that the poise on the tare-bar can

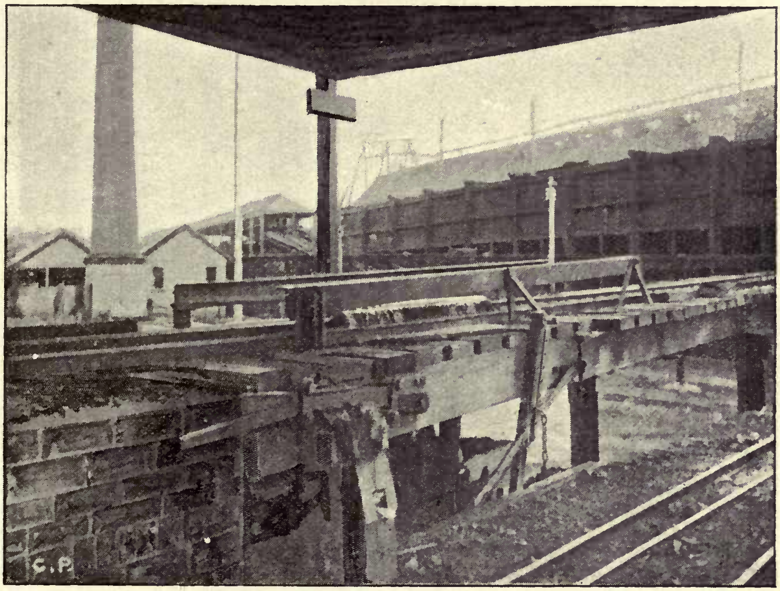


Fig. 213.—Check Brake.

be placed at the necessary mark. The poise on the weigh-bar is then placed at some mark a little less than the minimum net weight of coal likely to be in a skip. By this means the weight of the empty skip and the minimum net weight of coal is fixed. Any variations above this is automatically shown on the quadrant, and is added to the former minimum net weight set on the weigh-bar. The whole machine is cased in wood secured to the floor, so as to protect it from dirt, and also from being tampered with.

A creeper chain takes the skips to the tippler. An occasional pair of wheels are attached to the creeper chain, which

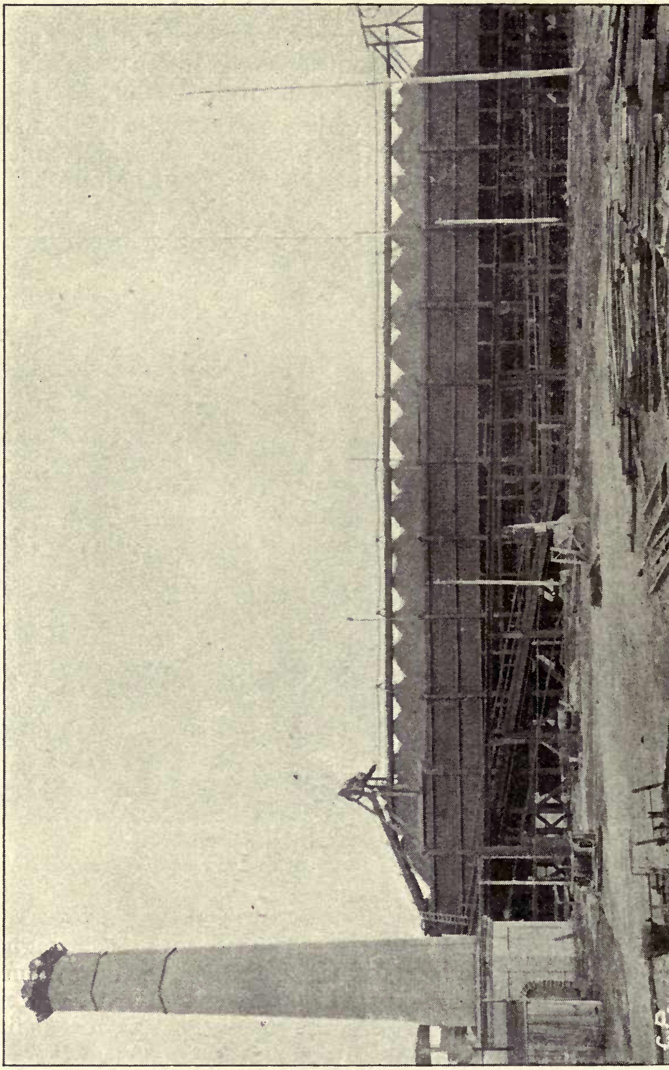


Fig. 214.—Coal Boxes.

run in a trough. At the foot of the incline is a chock working on a hinge and weighted at one end; the chock is curved, and on its back recesses are cut for the axles of the skips to rest

in. At first the chock was used singly, but it was found to slew the skips off the track, so now a pair are used together. Ordinary chocks are placed on the incline in case a horn of the creeper chain should break, and set the skips free. The creeper chain is tightened by screwing up a sliding pulley; if the chain stretches too much, a link is taken out.

The loaded skips are run into balanced side tipplers, where they are held in place by angle iron fixed just above their wheels. The empty skip is pushed off by the on-coming full skip, and runs down an incline towards the mouth of the tunnel. Two or three check brakes are placed along the line, so as to control the speed of the skips. This brake is the invention of Edward Davies, the company's engineer. It consists of a bar of angle iron arranged over each rail, so that it can come in contact with the tread of the wheel. That end of the angle-iron on the up side swings on a bolt, and is raised a little higher off the ground than the top of the wheels, so that the latter can pass under it easily, but the exit end is free and weighted, so that it presses on the tread of the wheels that pass underneath it. Such brakes may be made so that they can be raised by hand (Fig. 213), and release the skip should it be held fast.

From the tippler the coal falls on to a screen. A double gate is arranged part of the way down each screen. It is kept in place by weights, and can be opened by pulling a rod. The round coal is allowed to fall into a counterbalanced shoot. When lowered, the shoot drops the coal into waggons, thus saving shovelling. The slack falls through the screens into slack boxes, from which it can be loaded into waggons, but if there are no orders to be carried out, the slack is taken by scraper conveyors up to storage slack boxes capable of holding a little over 2000 tons. (Fig. 214.) The scraper conveyor is kept down at the hollow by sprocket holding-down pulleys. The creeper chain and scraper conveyor are worked by an old jig rope, the different sections being thrown in and out of gear by friction clutches. The tightening pulley and weight for the rope is shown in Fig. 215. There are several horizontal sliding gates in the bottom of the storage slack boxes, so that if required a train of 40 waggons can be quickly loaded by passing underneath, men on platforms opening the gates with lever handles. A scraper conveyor also takes coal to the Lancashire boilers. The boilers have a bar in front of the firebox for tools to rest on when cleaning them out. There is a special door at the back of the screen-box, through which the miners obtain the supply of coal allowed them for domestic purposes.

Electricity is used at this colliery for hoists, pumps and lighting. Only low tension current, of 220 volts, is employed. The cables are led down the little tunnel. The original electric plant consisted of a Westinghouse direct current, 4 pole generator of 45k.w., driven by a compound Westinghouse engine provided with a fly-wheel governor. This has been superseded by a Siemens Bros.' direct current, 6 pole generator, compound wound, of 200k.w., driven by a Bellis and Morcom engine of 300 h.p. It has a belt driven automatic cylinder lubricator, a gauge for the pressure of oil on the bear-

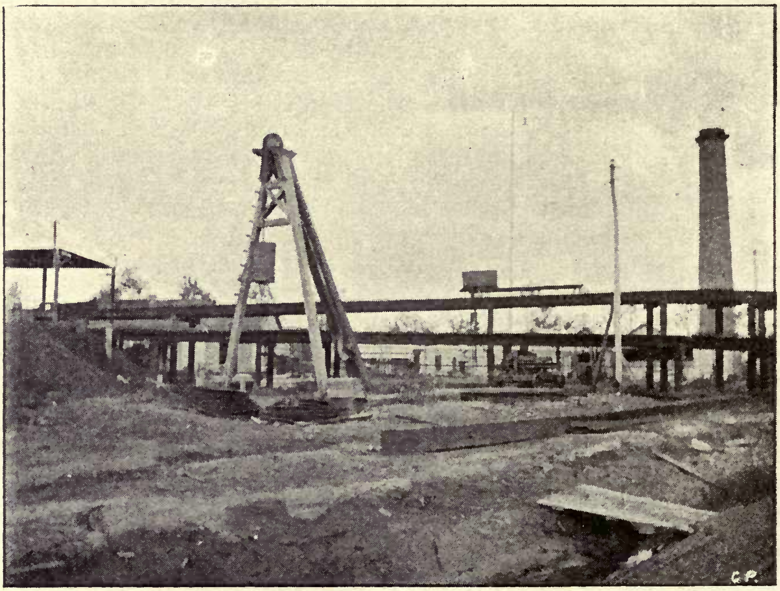


Fig. 215.—Tension Pulley.

ings, the pressure being kept at 15 to 20lbs., and another gauge for the pressure of steam in the cylinder. A Worthington oil separator, condenser and heater, are used. The oil is separated in a vessel with baffle plates; then the steam passes through 640 brass tubes, about ½in. in diameter, cooled by pit water, which circulates round them. The condensed water then goes to a heater warmed by exhaust steam from the condenser pump. In the power-houses are installed a Belliss-Siemen's 200k.w. set, and a Westinghouse 45k.w. set; also a switchboard made up of two generator panels and three feeder panels, having two 200 amp. feeder circuits.

Pelaw Main.

This is one of the collieries belonging to Messrs. Jas. and Alex. Brown. It is on a leasehold, and adjoins their freehold property of Richmond Vale. Pelaw Main is about ten years old, and employs some 800 hands. It is under the management of Mr. R. Arbuckle.

Pelaw Main is at present worked from tunnels, but there are also two shafts, one of which is used for conducting air pipes from the air compressors to the machinery below; also a steam pipe for a Blake pump at the bottom, and a main and tail rope for hauling purposes. The other shaft will eventually be used for ventilation purposes.

The seam is a very fine one to work, being 17 to 20ft. thick, and remarkably free from shale bands. The roof is conglomerate. The coal is taken out in two workings. Were the seams thicker, it would not be so easy to win. The mine is worked on the triple entry system. The main intake heading is in the centre, and on either side are the bord headings. The bords break away from the latter, not at right angles, as then on account of the facings it would be impossible to keep the top coal up, but at a slight angle to the facings, which also gives the bord a grade of about 1 in 12. At the upper part of the mine the bords and pillars are both 8 yards wide, but as the cover gets thicker the bords are made 6 yards, and the pillars 10 yards. In the first working the bords are made 7ft. 6in. to 10ft. high, and in the second working the coal is dropped from the roof. No attempt has been made to win the pillars yet. Slants, at a greater angle to the facing than the bords, are driven every 60 yards apart, which gives the track a grade of from 1 in 15 to 1 in 18, which is convenient for wheeling. These slants, which cut up the bords into lengths of 60 yards, lessen the distance for conveying coal from the faces to the main heading. Where a dyke or fault occurs this is used as a natural barrier, but otherwise a coal barrier one chain thick is left every 300 yards. At the fourth bord length, the far end of the bord is narrowed down, and a brick stopping put in; bricks and mortar are kept in readiness near the intake and return to each district, so that should a fire take place, that portion of the mine can be quickly sealed off.

The coal, which is hard to work with a hand pick, is undercut by Ingersoll punches worked by compressed air. There are 35 of these machines in use, worked by machine men and their helpers, the latter shovelling the cuttings away and helping to move the machine.

The borer then comes along with a No. 2 Little Giant air drill. The cutting portion is an ordinary auger, such as is used for boring holes in coal, but in this case it is revolved by compressed air instead of by hand, and does it work very much quicker. The operator holds the machine by two handles, in one of which is the valve for turning the air on or off. The handles serve to guide the machine, the forward motion is given by pressing against it with the body. Boring is done by wages men, who bore a hole 6ft. deep in 1½ minutes. Fig. 216 gives

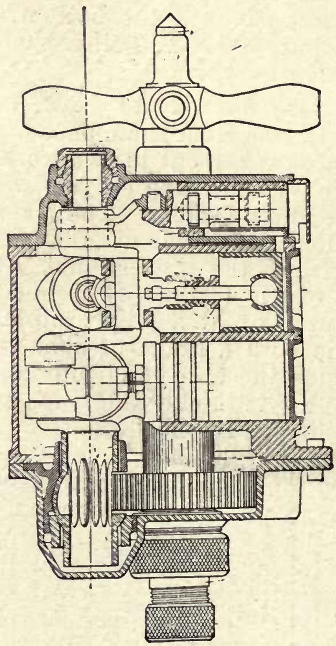


Fig. 216.—"Little Giant" Piston Air Drills.

a section of the working portion of the machine. These drills are of the balanced piston type, and consist of four single acting cylinders arranged in pairs, each pair of pistons being connected to opposite wrists of a double crank shaft. Each piston of each pair travels in opposite directions at all parts of the stroke, thereby insuring a smooth running machine. The crank shaft revolves in an enclosed chamber designed to be kept partly filled with the lubricant. This machine weighs 15lbs., makes 600 revolutions per minute with 90lbs. pressure, and uses 20 cubic feet free air per minute.

When the holes are bored, the shot firer comes along, charges and fires them as required, and fills the broken coal

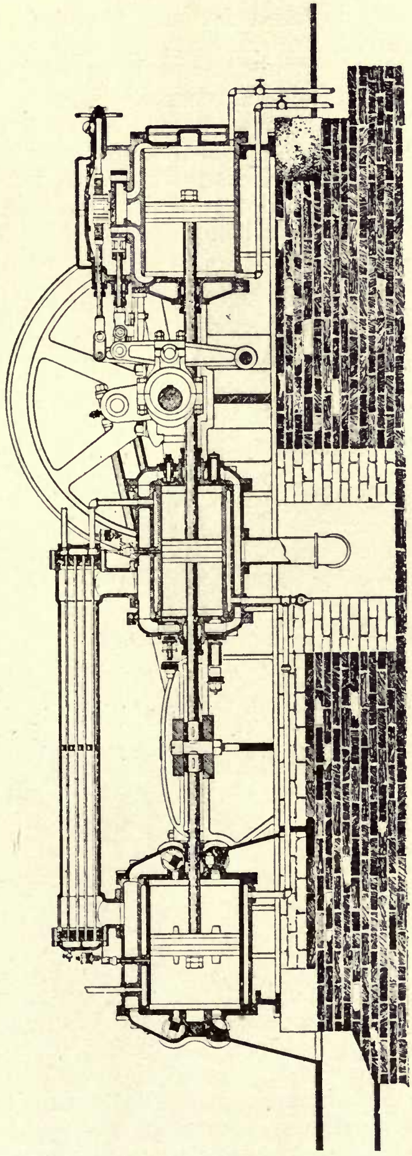


Fig. 217.—Norwalk Compound Air Compressor.

into skips. Monobel is the permitted explosive used, except when shooting in wet places or stone, when saxonite is em-

ployed. The shots are fired by means of electricity, Nobel's low tension fuses and exploder being used.

Compressed air is used for the Ingersoll punches, the Little Giant air drill, and a Tangye-Snow pump. There are air receivers underground as well as on the surface; in fact, each district has its own receiver. The main air pipe is six inches in diameter, from which three-inch branch pipes are led into the slants, one and a half inch pipes being provided for each bord. The air is compressed in a Norwalk tandem compound compressor, with mechanical valves, and provided with an overhead intercooler, supplemented by two Ingersoll-

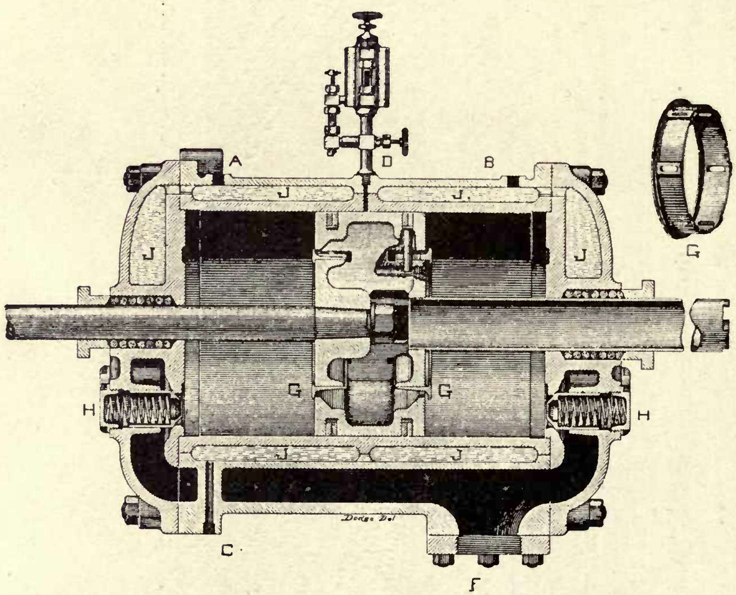


Fig. 218.—Ingersoll-Serjeant Compressor.

Sergeant single cylinder compressors. In the Norwalk compressor the air and steam cylinders are arranged tandem. (Fig. 217.) The object of compounding the air cylinders is to average the resistance throughout the stroke, instead of having an excessive maximum resistance at the end of the stroke, as is the case with single compressors. By having the final pressure in the intake cylinder comparatively light, the loss in capacity due to clearance is reduced to the smallest amount; moreover, the cylinders are water jacketed, which helps to

cool the air. The intercooler between the two air cylinders is composed of a pipe containing copper tubes, that split the air compressed in the low pressure cylinder into thin streams, which are cooled by circulating water. By cooling the air that has been heated by compression, the tendency to expand is decreased, and therefore the high pressure cylinder can do more effective work. The mechanical inlet and out valves are of the Corliss pattern.

The Ingersoll-Sergeant is a straight line single air cylinder compressor. It does not take up much space, every part of the machine is very accessible, and the piston can be removed from either cylinder in a short time. The air cylinder is completely jacketed, including both heads, near where the air is in greatest compression, and consequently is hottest. The free air enters the cylinder through the piston. In Fig. 218, A is the circulating water inlet; B the circulating water outlet; C the water-jacketed drain pipe; D the oil hole for the automatic oil cup; E the air inlet, through piston inlet pipe; F air discharge; G the pison inlet valve; H discharge valves; I water jacket. The two inlet valves located in the piston, together with the tube, are carried backwards and forwards with the piston. The large ring air inlet valve admits a large area of opening with but a small throw of valve, thus quickly opening a large supply port. The movement of the valve is only about a quarter of an inch. It is positive in its action. The valve on that face of the piston which is towards the direction of movement is closed, while the one on the other face is open.

The haulage consists of two endless rope systems, one in each tunnel. Each rope has a total length of from $3\frac{1}{2}$ to 4 miles, and has a loop branch. These ropes are driven by a pair of R. and J. Morison and Bearby engines. Three skips are run in a set, clipped to the rope with screw clips. Monkeys, which are bars of wrought iron bent at right angle, and pivoted at the bend, are arranged all the way down the incline on the up track, so as to catch any skips that might break away. There is also a main and tail rope system with two branches, worked from the surface. Electric secondary haulage is being installed for the branches. The axles of the skips are square where they enter the hub of the wheels. They are fastened on by driving in wooden wedges, and tightened by driving iron wedges into the wood.

Electric wire signals are used, and telephones are fitted up throughout the colliery.

A belt driven Schiel fan, 12ft. 6in. in diameter, is used for ventilating the colliery. A spare engine is provided, arranged end on to the other. At the new air shaft, a Sirocco fan will

be installed. The blades of this fan are very numerous (Fig. 219), and their depth is very shallow in relation to the diameter of the fan, while their axial measurement is very long. The outer edges of the blades are curved forward in the direction of rotation, and the air passages between the blades are open towards the inflowing air. The inlet and outlet open-

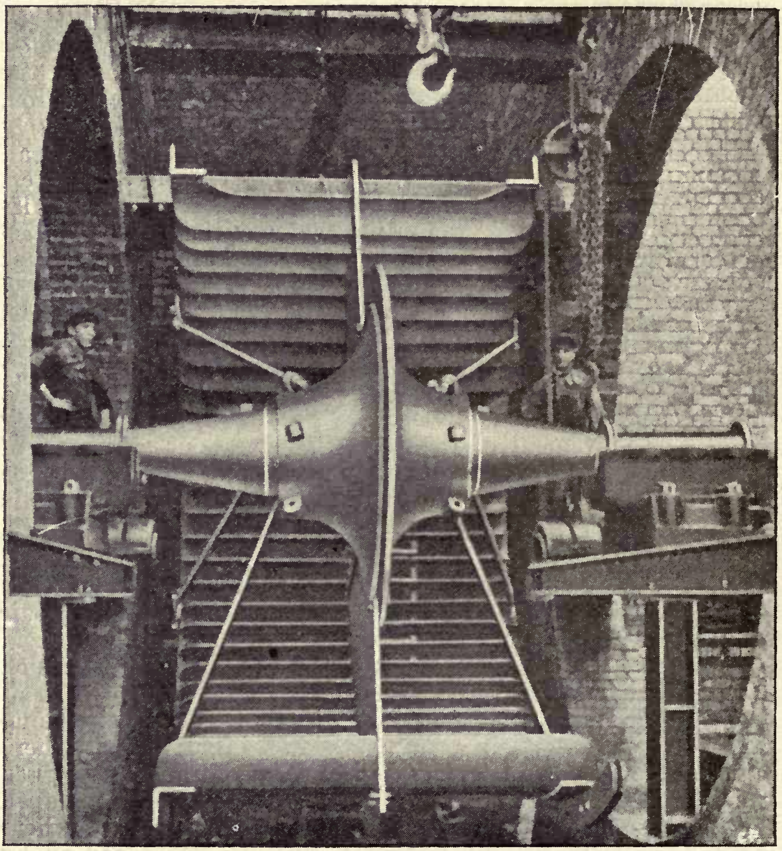


Fig. 219.—Sirocco Fan.

ings are of approximately equal diameter to that of the fan itself, and very much larger in proportion than that of other centrifugal fans. The volume of air discharged is greater than that of other centrifugal fans of equal diameter. The frictional resistance to the passage of a given volume of air is

less, consequently the efficiency in actual work done for the power supplied is much more. The detrimental eddies which occur in other fans are obviated by the construction of the Sirocco. This fan has a double inlet, and is 190in. in diameter. It is driven at 200 r.p.m., and is capable of exhausting 350,000 cubic feet of air per minute, against 5½in. water gauge. This requires 230 b.h.p. It is driven by ropes from a 3 phase, 50 period, 3300 volt motor, of 500 h.p. Ropes are better than belts for driving fans, for if a rope breaks the others will drive the fan till the men have time to get out of the mine before it is necessary to stop for repairs. The bearing surfaces

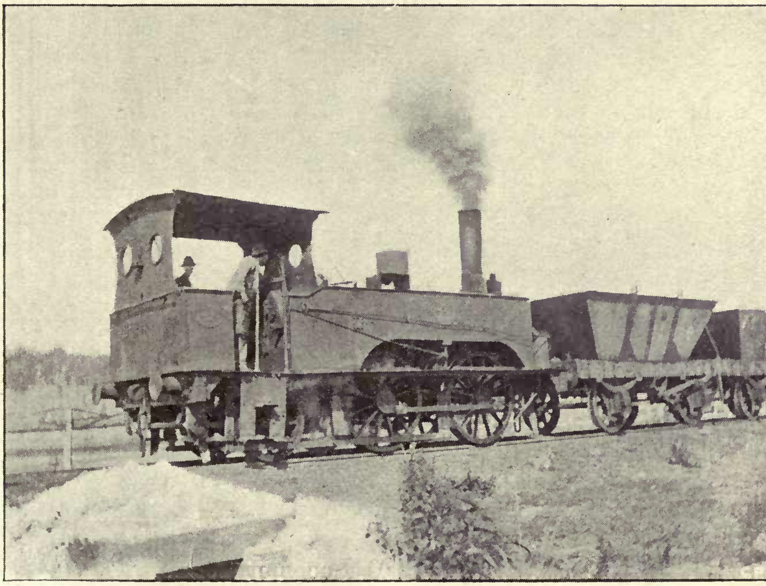


Fig. 220.—Locomotive Built in 1858.

for the shafting of the fan are very wide, and lined with white metal. They are fitted with leather washers at each end to make them dust proof. The bearings are lubricated by automatic ring lubricators. An adjustable sole plate is provided, which is wedge-shaped. By screwing this in or out, the bearings can be aligned in a very short time should the foundation settle. It is also useful when the lower bush has to be removed, for, by dropping the lower half of the bearing, the bush can be slipped round the shafting and taken out.

The coal, when raised, is tipped from revolving side tipplers, worked by friction gear, on to shaking screens. The round coal passes to a travelling picking belt, which can be thrown in and out of gear by a friction clutch. A Pooley's weighbridge is used for waggons.

This company is still running two small locomotives built in 1856 for use in the Crimean war (Fig. 220), but they have had cabs added. In comparison to this, their No. 9 is the finest privately-owned locomotive in New South Wales. (Fig. 221.) It weighs 90 tons when ready for work, has 21in. diameter cylinders and it has eight wheels coupled. The front wheels are bogies, and the back radial. This is a tank engine, and was made by Kitson, of Leeds.

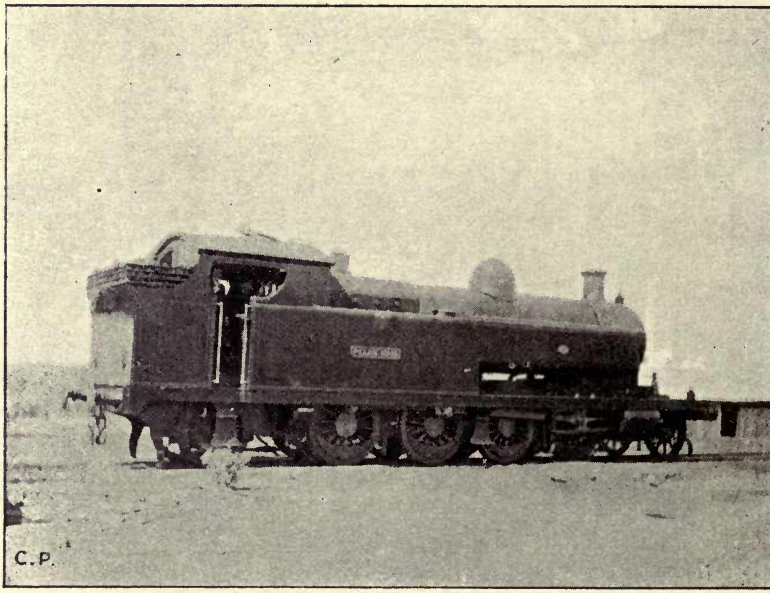


Fig. 221.—No. 9 Locomotive.

The Lancashire boilers are fitted with Triumph automatic stokers. (Fig. 222.) Automatic stokers effect economy of fuel and economy of labour. More perfect combustion is obtained than by hand, and the evaporation is higher, more uniform, and more easily regulated. The fire doors being kept closed, less smoke is made than when frequently opened for hand feeding; also cold air is prevented from playing on the hot plates and damaging the boiler. The slack is brought to the boilers

by scraper conveyors, and is then fed slowly into the fire-box and pushed gradually forward by the movement of the fire-bars, which have a backward and forward up and down motion. A vertical spindle at the side of each boiler has a worm on either end. This spindle is driven from a horizontal shafting, on which are a fast and loose pulley, by means of a worm and

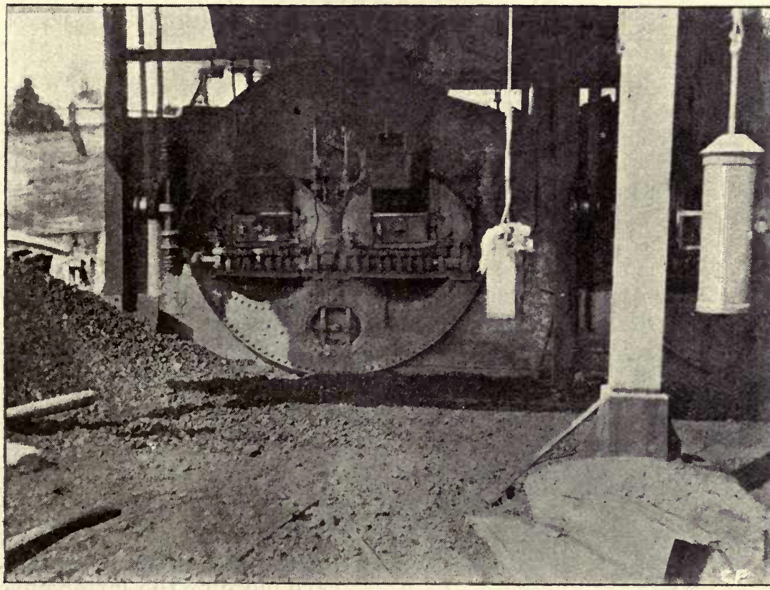


Fig. 222.—Automatic Stoker.

worm wheels. The top part of the spindle actuates a shovel at the bottom of the coal box, four cams pushing the shovel backwards in turn, while a spring forces it forward again. The lower part of the spindle imparts motion to the fire-bars.

Neath Colliery.

The Wickham and Bullock Island Coal Company owns this colliery, which is managed by Mr. Clem Jones. Here the lower Greta seam is all in one. A bore struck coal on 3rd October, 1905, at 286ft., where it was 26ft. thick without the bands, or 27ft. 10in. including bands. Shafts were started the first week in May, 1906, and the first train of coal was despatched to the Newcastle dyke on 26th February, 1907. This is a shaft mine. The main shaft is 14ft. in diameter in the clear, 299ft. deep to the roof of the seam, and it is lined

from top to bottom with bricks. It has steel rail guides at the sides for the cages to run on, so as not to obstruct ventilation with centre buntons. The air shaft is 12ft. diameter in the clear. It has one cage with four rope guides. The roof of the air drift is made of planks covered with felt and lead on the outside where exposed to the weather, so as to make it air tight. Windows at this shaft are placed opposite each other, to enable the driver to see the position of the cage at the landing place. They have an iron Guibal-Walker fan, 16ft. diameter, and 6ft. wide, open at both sides, and there is a fixed Walker shutter at the exit end. Steam exhaust and water pipes occupy this shaft. When sinking the air shaft, much trouble was experienced for a few weeks by a heavy flow of water about 16ft. from the bottom. The water is now kept down with a Tangye pump 12in. by 5in. by 24in., and they have a spare Tangye 14in. by 6in. by 24in. in case of emergency.

The main winding engine is a duplex 20in. diameter cylinder, 3ft. stroke, with an 8ft. drum, on which two ropes are wound. The pit head frame is of wood, standing in cast-iron shoes.

The N.W. heading is about half a mile long, with a grade of 1 in 14. The coal is mostly drawn by horses. There are stables both underground and at the surface.

The coal is worked in 8 yard bords, 14 yard pillars being left between them. The pillars are taken out 7ft. to 10ft. high; the top coal has not been dropped yet. Every two chains cut-throughs are put in. At first all the hewing was done by hand pick, but now they have one Jeffrey shortwall machine, and two Jeffrey breast machines. Five more of the latter have been ordered. Naked lights are used in this colliery.

The first electric plant they had was for lighting purposes, and consisted of an $8\frac{3}{4}$ h.p. Siemens 220 volt. direct current, 4 pole motor, belt-driven from a vertical Tangye engine, 7in. by 7in. They now have a 150k.w. Siemen's generator, 500-550 volts, 420 r.p.m. direct coupled to a Bellis-Morcom engine, with 13in. and 21in. cylinders, and 9in. stroke, which uses steam at 150lbs. The steam is supplied by a Thompson boiler 30ft. long by 8ft. 3in. in diameter.

A Marcus conveyor, 62ft. long, the first to be installed in N.S.W., for screening and cleaning purposes, is belt driven by a 10 h.p. motor, which has 1060 revolutions per minute. The conveyor speed is 61ft. per minute. After separation, the coal is conveyed by a under trough for 22ft. to the required position over the small coal waggon road. The skips are returned to the shaft by a creeper chain travelling at the speed of 50ft. per minute, motion being imparted to it

through spur gearing to a 5 h.p. motor. A three skip tippler, 11ft. 6in. diameter, delivers the coal on to the conveyor through a shoot.

Abermain Colliery.

This colliery, formerly known as the Silkstone Coal Mine, is nine years old, and belongs to the Abermain Colliery Company Ltd. The manager is Mr. J. Jeffries.

The seam dips one in eighteen, and is worked from tunnels. (Fig. 223.) All the top seam is worked.

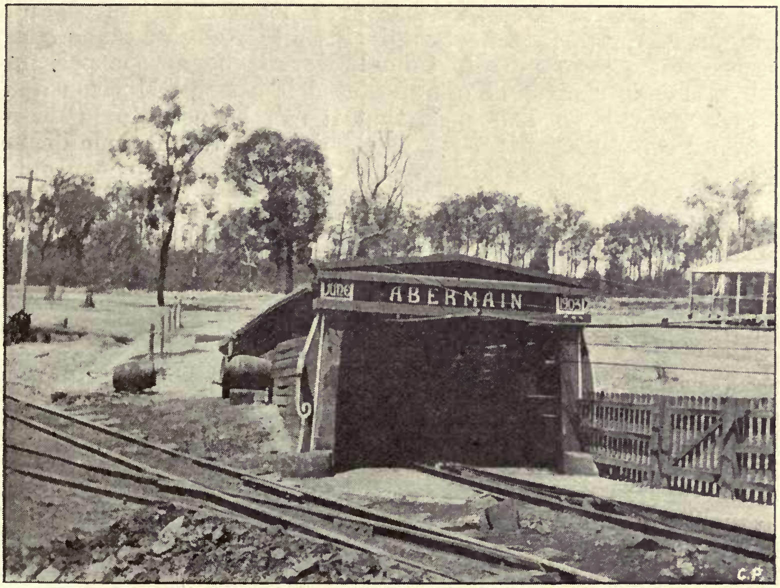


Fig. 223.—Entrance to Main Tunnel.

The more recent workings are laid out in panels of 200 yards. Originally all bords were taken out on a level course, but now levels are driven off the main places, and bords turned off from them to the rise. The bords are 8 yards wide, and the pillars 9 yards. No pillars have been worked as yet. Cut-throughs are made every 44 yards. The pillar between a pair of levels is one chain wide; the barrier pillar at the end of the bord, which is not broken through, is 11 yards wide.

The coal is undercut by 15 Jeffrey electric chain breast machines.

This is a naked light mine. The 30ft. diameter Waddle fan is direct driven by a Morison and Bearby engine made in duplicate. The fan has bearings in the air drift, as well as in the engine room.

A Mather and Platt centrifugal pump raises 50,000 gallons of water per hour against a head of 120ft. There are also five electrically driven three-throw vertical Allantown pumps. One is driven direct by a Verety standard motor of 5 h.p. The others are belt driven from Westinghouse motors.

An engine plane is worked down the main dip tunnel as far as the air shaft, and also serves a crosscut. The main hauling engine, built by Morison and Bearby, is geared; the drum being wide, has to have guide sheaves between it and the pit top, on account of the fleet angle. Another engine plane continues down the main dip tunnel, worked by a rope passing down the air shaft. The engine used is a small Morison and Bearby, with two drums, so that it can be used for a main and tail rope system if necessary, but just now only one drum is used. The gearing is in front of the engine; some people prefer this to having the gearing at the back, as any pull on the drum has a tendency to make the cogs of adjoining wheels mesh tighter together instead of pulling apart, when in the latter case control of the drum might be lost. On the other hand, front gearing sometimes gets in the way of the lower rope.

About 22 skips are brought out in a set. The last skip has a "bull," or dragbar, so as to prevent the skips from running down hill in case the rope should part.

There is a throw-off at the top end of the flat between the two engine planes, also at the bottom of the lower engine plane. This consists of about 10ft. of 60lb. iron rail with its down hill end hinged to a plug let into the roof. The loose end is held up by a catch attached to a chain and rope that pass round sheaves. The boy at the flat can tell by the sound if the skips are running away, in which case he puts the throw-off into action by pulling the line when the loose end of the rail falls down, and the skips rush up against it. The first two skips are generally smashed up, but the rest are saved.

At the pit top there are two shaking screens, three stationary screens, and two picking belts. The slack box with the hopper truck, which is drawn up the incline by a rope from an engine, can be seen in Fig. 224.

The boiler plant at the main entrance consists of three Cornish and one Lancashire boiler; while at the air shaft there are two Cornish boilers.

In the powerhouse, there are two Jeffrey compound wound 6 pole generators, one of 100k.w., the other of 80k.w., worked

in parallel. The voltage is 250. These are driven by belts from McEwan engines, which are 168 h.p. and 124 h.p. respectively. These engines do excellent work, and require a minimum of repairs.

Hebburn Colliery.

The township of Weston has grown up about this colliery, which is one of those owned by the A. A. Company, whose general manager, Mr. R. A. Harle, looks after it. The colliery is only six years old.

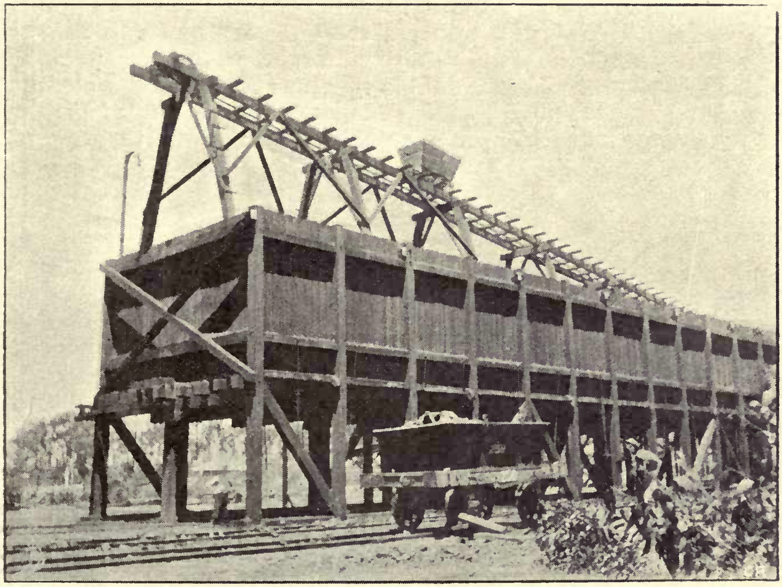


Fig. 224.—Slack Box.

Both the top and bottom split of the bottom seam are worked. The top split is from 6ft. to 10ft. thick, while the bottom split is 4ft. 6in. to 6ft. 6in. thick, and they are separated by 20ft. to 50ft. of rock. Both splits are worked independently, but are connected by stone drifts. The coal is extracted on the bord and pillar system, the pillars of both workings being arranged one above the other. The mine is divided into panels 20 chains square, with barrier pillars between, $1\frac{1}{2}$ chains wide. The bords are 6 yards wide, and the pillars 16 yards. There are only working bords and cut-throughs at present. They have not commenced drawing the pillars, but when

they do will begin by taking out those of the top split first. The bords are all worked up hill from one side of a heading only, since the coal falls forward better. There is natural drainage, and the full skips have a down hill run. The road ways are given a grade of half an inch to the yard.

They use both the main and tail rope and the endless rope systems of haulage. The main and tail rope works both splits in the seam, and serves five districts altogether. It brings the skips to the endless rope, which takes them to the surface, and to the tumbler at the pit top. A Tangye engine, 20in. by 40in., geared 3 to 1, with 6ft. drums, and provided with steam reversing gear, is used for the main and tail rope. There are 35 skips to a set, and the last skip has a "bull" or drag bar attached. This "bull" is forked at the end near the skip, and each arm has a double hook. (Fig. 225.) This end is hooked on to the skip, while the pointed end is hung from the tail rope, so as to keep it from knocking against the rollers.

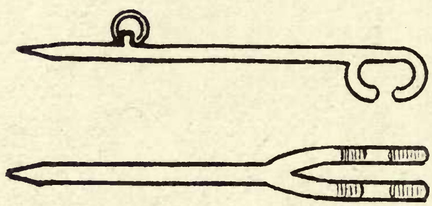


Fig. 225.—Bull and Dragbar.

Should the main rope break, the tail rope becomes slack and the "bull" falls, so that it can stick into the ground. The skips travelling up hill must stop momentarily after the main rope breaks before they start down in the opposite direction. It is then, before the pace is accelerated, that the "bull" must act.

The endless rope engine is a Robey 11in. by 22in., geared 15 to 1, fitted with a Richardson patent cut-off gear, which does not use more steam than absolutely necessary. The skips are attached to the rope by Smallman's clip, in which a wedge, worked by a lever, forces the cheeks of the clip apart at the top, and causes them to grip the rope below.

They work with 16 Jeffrey chain breast machines and one Goodman, all electrically driven. This is the only pit in the district to use safety lamps with coal cutters. Two of the Jeffrey and the Goodman make 7ft. by 3ft. cuts, while 14 Jeffrey make a 6ft. by 3ft. cut. The chief trouble with the electrical part is burnt out starting boxes and damaged trailing cables;

the mechanical troubles are broken cutter chains and trolley chains. Most of the breakages are due to carelessness on the part of the men.

As chain breast machines require 12ft. space to work in, when the roof is tender, the coal has to be undercut by hand. If not too bad, the roof may be supported by 12ft. slabs resting on two posts.

Two single pole joint boxes are used at the entrance to each going bord for connecting the trailing cable to the main. Each pole having its own box, there is no possible chance of accidental short circuiting. By suitable mechanism, the hole through which the plug enters is closed by a door which cannot open while the switch is closed. The main cable is carried along the roof of the heading on the bord side, so that the trailing cable shall not have to cross the rails and run the risk of being damaged by passing skips.

To save a long detour of half a mile or a mile for the cables from the workings of the upper split to those of the lower split, a borehole, 2½in. in diameter, was put down by hand for 16ft. It was lined with a 2in. tube, which was cemented in; the cable was passed down this and fixed with bitumen.

The trailing cable is a twin, sometimes round in section and covered with plaited greenhide as a protection; and sometimes it is flat in section, the cables being laid alongside each other instead of being worked in with strands, as in the case of the round cable. The flat cables do not coil up so well as the round. They are run through rubber hose for protection.

The old electric plant consisted of a McEwan engine which drove a Jeffrey direct current generator for low tension. There are equalising switches to equalise the power of the main and spare generators. The recent installment consists of two Ernest Scott and Mountain generators, each of 100k.w., driven by 14 ropes from a Robey and Co.'s compound engine, 18in. and 28in. diameter cylinders, and 3ft. stroke. All the shaft bearings for the dynamos are on the ball and socket principle, which allows for a certain amount of give and take, and adjusts any irregularities in alignment. There are two slip rings for self lubricating purposes in each bearing, and there is a sufficient supply of oil to last the bearing for three months. There is a flexible coupling between the rope pulley and each motor. Both halves of the coupling have 6 bolts arranged in a circle, but the circles are of different radii. A belt is worked in and out between the bolts of the two halves, and the whole covered with a steel shell. The coupling can be readily disconnected by slipping the shell on one side and pushing the belt off. All the brushes on the dynamo can be adjusted simultaneously by a hand screw, or each brush can be adjusted

separately if necessary. Any dust that settles in the dynamo is cleaned out by means of compressed air, which can be handled through a hose.

The boiler plant consists of a nest of Lancashire boilers, 8ft. 6in. in diameter and 30ft. long, in which steam is generated at a pressure of 120lbs. An A.B.C. fan is fitted to the return flue of the boiler to create an induced draft. (Fig. 226.) By using such a draft the stoker is able to thoroughly burn the coal. When the fan is in commission, both flue doors are opened.

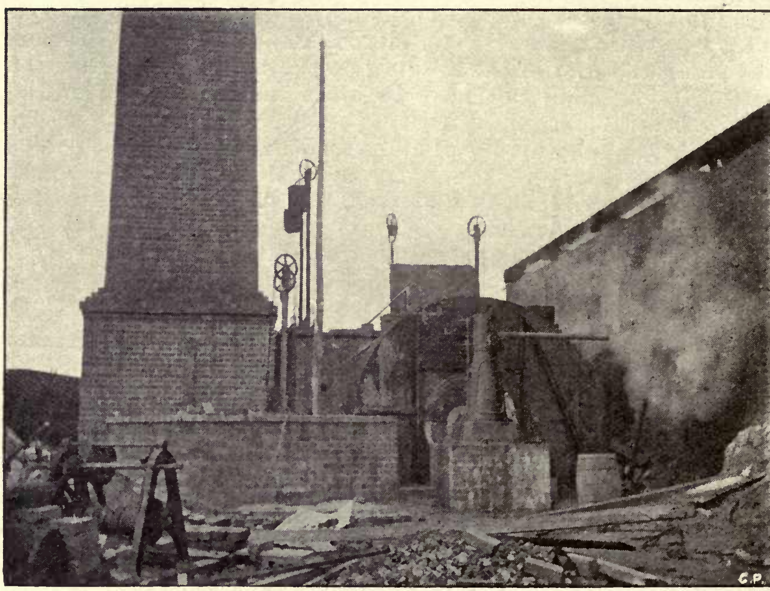


Fig. 226.—A.B.C. Fan for Induced Draught.

A Capell fan, 12ft. in diameter by 9ft. wide, with double inlet, is driven by a Robey engine, 22in. by 44in., to ventilate the mine. The engine is provided with a Richardson governor and shut-off gear. With a 2in. water gauge, this fan will pass 220,000 cubic feet air.

An Ingersoll-Sergeant straight line single air compressor is used to supply motive power for the pumps. The pumps are 6 to 7 Tangye, one Evans and one Mather and Platt four chamber high lift centrifugal, which lifts the water 200ft.

The heapstead is built on wrought iron girders supported on cast-iron columns. The full skips are raised sufficiently

high by the endless rope so that they can gravitate to the tippler, and after being tipped, they are pushed out by the next skip, and gravitate to the empty line. Drop chocks, that can be raised between the rails, are used on the empty or return line in case of a run away, while monkey chocks are used on the up line. The side tipplers were made by Head-Wrighton and Co., of Stockton on Tees, England. The underside of the tippler is weighted. It is set in motion by a friction wheel which is brought in contact with it by means of a lever. This was originally made self acting, but as a man had to be in charge, it was found better to let him do the work, so as to keep him fully employed. Each tippler is capable of dealing with 3 tons per minute. From the tippler the coal passes to a shaking screen, and the round coal falls on to a 70ft. by 4ft. 6in. picking belt. The small coal storage has a capacity of 4000 tons. The bottom portion is brick-lined, the Jeffrey electrically driven run-a-round conveyor over it being supported on a steel structure.

The company does all its own brass castings, and in the shops they have a shaping machine, 2 drilling machines, punch and shearing machine, steam hammer, and five forges with forced draft. The shafting runs the full length of the shop, and is driven by a Robey engine.

Aberdare Colliery.

This colliery belongs to the Caledonian Coal Company Ltd., for which Mr. D. McGeachie is superintendent. It is situated at Weston, near Cessnock. The seam being worked is 32ft. thick, but only 8ft. 6in. of the lower coal is won. The mine is laid out in panels a quarter of a mile square, with a barrier pillar one chain wide between them. The coal is extracted on the bord and pillar system, the former being 8 yards wide, and the latter 16 yards.

The seam is worked from brick-lined circular shafts about 500ft. deep. The downcast shaft has a steel head frame. There are three rope guides for each cage, and two dead ropes are hung between the cages to prevent them from swaying too much. The guide ropes have their upper ends fastened by passing them through eye bolts at the top of the head frame, and clamping them. The hoist consists of a pair of engines, with 34in. diameter cylinders and 48in. stroke. These drive a 12ft. diameter drum with a brake path round the middle. The driver's seat is high up, and so situated that he has a good view of the pit top.

A band rope driven from the surface by an engine passes down the main shaft to a clutch room underground, where it

works two endless rope haulages, which travel at the rate of $1\frac{1}{2}$ to $1\frac{3}{4}$ miles per hour. The endless rope is fed by two jigs on a grade of 1 in 18, and a main and tail rope driven from the surface, which passes down the air shaft. Electric secondary haulage is about to be installed.

The air shaft (Fig. 227) has a wooden head frame, and is provided with a cage that runs on two rope guides. There is a special approach to the shaft for men, provided with an air lock. The fan used is a 12ft. Capell fan, for which there is a duplicate engine.

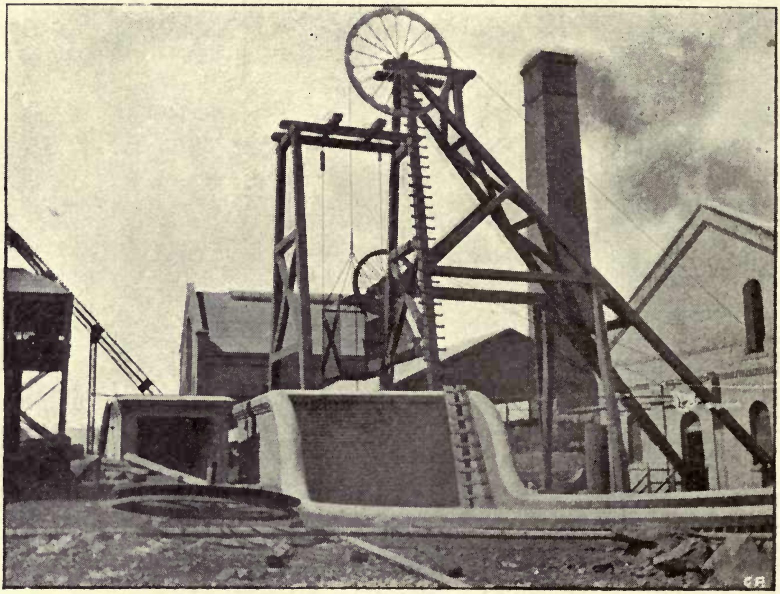


Fig. 227.—Air Shaft.

Seventy-five per cent. of the coal won is undercut by machines, of which there are 12 Sullivan shortwall machines, and 4 Jeffrey chain breast machines. The pick and chisel points of these machines after being shaped by the blacksmith are finished off on an emery wheel.

Four Tangye three-throw pumps, 7in. by 6in., driven by 10 h.p. electric motors, are used for pumping out the dip faces. The new pump, a three-throw 9in. by 12in., will supplant the present pumps, and will raise 22,000 gallons of water against

a head of 500ft. per hour. It will be rope driven from a 95 h.p. electric motor, built by Scott and Mountain, of Newcastle-on-Tyne.

There are eight multitubular boilers by A. Goninan and Co., and one Lancashire boiler by John Thompson, of Wolverhampton, England, designed with corrugated flues, for a working pressure of 150lbs. This boiler is used for the power-house only. Feed water is pumped from a dam half a mile away by an electrically driven 7in. by 6in. three-throw pump controlled from the mine. Two old egg end boilers are used as treatment tanks for where they are obliged to use pit water, and as water heaters where fresh water can be obtained.

The fitting shop is provided with a planing machine, screwing machine, drilling machine, and lathe.

The blacksmith's shop has four forges, the air for which is supplied by a blower worked off a belt by an electric motor. There is also a shearing and punching machine, and a steam hammer.

Other buildings include a carpenter's shop, electric fitting shop, store, etc.

The power-house contains an Ames high speed engine, which belt drives a 500 volt continuous current generator made by the General Electric Company. This is used to work a 95 h.p. motor direct coupled to a Worthington five stage turbine pump, which is used for pumping from the sump at the bottom of the shaft to the surface.

Two sets of Bellis and Morcom high speed engines are direct coupled to British Thompson-Houston 100k.w. 250 volt. generator, used to supply power for coal-cutting, pumping, and lighting.

One set of Ernest Scott and Mountain's high speed engines are direct coupled to a 200k.w. 250 volt generator.

The three latter generators will be replaced by three sets of high pressure, 2200 volts, 3 phase machines, and there will be four sub-stations underground, each of 100k.w. Each sub-station will consist of a 150 h.p., 2200 volt, three phase motor, direct coupled to 100k.w., 250 volts generator, for low tension distribution in the pit to coal cutters and pumps.

In the same building is an auxiliary winding engine for the air shaft, and the main and tail rope engine.

The main low tension electric cable is passed down the shaft, and is clamped to an old winding rope every 15ft., which serves as a support.

The high tension cable is placed in an iron pipe on the far side of the shaft. The pipe is clamped to the wall. At the top of the shaft are boxes for connecting the shaft-cable with the surface-cable.

Every month the trailing cable is tested by passing it through a shallow bath of water from one reel to another. An electric main carrying 500 volts is connected with one end of the trailing cable through a special high pressure voltmeter. The other main is connected with an iron plate, and dropped into the water tank; by this means a defective place may be localised in the section being tested. If one exists, it is then repaired and again tested. After the whole cable has been treated in this manner, it is coiled up and placed in a large metal-lined water tank for six hours, and then tested by connecting one end kept out of the water to the main cable, and

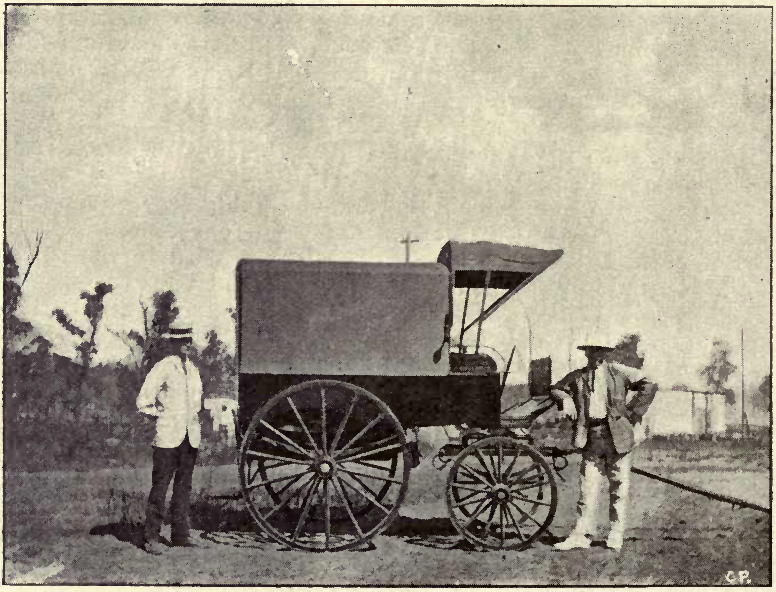


Fig. 228.—Ambulance Waggon.

the other end to the metal lining of the tank, and using an ohm-meter. This must show a resistance of at least one megohm.

All about the surface works, as well as below, at suitable distances apart, stand water pipes are arranged in case of fire.

At the pit top there is the usual creeper chain, two rotating side tipplers for the coal, and an end tippler for the dirt box. The shaking screen has oblong-shaped holes cut in steel plates, and a shoot at the end provided with a gate. Scraper

conveyors take the slack to the slack box. An ambulance waggon (Fig. 228), properly fitted up, is kept in readiness at the mine in case of accidents.

The Aberdare Extended.

This colliery, situated at Cessnock, and adjoining the Aberdare colliery, also belongs to the Caledonian Coal Company Ltd. It is under the management of Mr. Ernest Humble.

The coal seam here is 32ft. 9in. thick, but at present they only extract 9ft. of the bottom coal.

The mine is opened up by two intake tunnels, with an intermediate return air-way between, and a back heading on the outside of each intake. The bords are placed at an angle of about 45 degrees to the back headings, so as to allow any water to gravitate towards the headings. Flats or clipping stations are placed every 100 yards. The bords are 8 yards wide, the

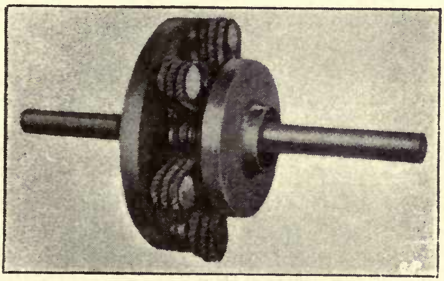


Fig. 229.—Flexible Coupling.

pillars 15 yards, and the cut-throughs at right angles to the bords are 4 yards wide.

The coal is undercut by three Sullivan machines, that cut across the face, and one Jeffrey breast machine.

At present they are working with an engine plane, the empties running into the mine by gravity, while the full skips are pulled out by steam, but this is only temporary, and will be replaced by an endless rope system, the engine for which is erected and has three Walker's pulleys, one for the main, the others for the two branches. All the ropes pass down the main tunnel. This is a naked lamp mine.

The Capell fan is 10ft. in diameter, and open at both sides. It is driven by ropes from two General Electric Company's motors of 105 h.p. each. These motors are connected to the shafting by a flexible coupling (Fig. 229), which takes up any slight movement of the shafting, misalignment, or end thrust,

without transmitting any effect, beyond a purely rotative one. These motors are not run at their full capacity. Later on, when the speed of the fan has to be increased, only one motor will be used, the other being held in reserve, in case of a breakdown.

There are two three-throw pumps, 7in. by 6in., also a small 2in. three-throw pump, all electrically direct driven. These are mounted on trollies, so that they can be hauled about from one place to another. When the lift becomes too great for these pumps, a turbine pump, now on the ground, will be installed at a permanent sump, from which it will pump to the surface.

The horses employed below are stabled at the surface, where there is accommodation for 32 animals.

At the pit top, after weighing, the skips are run into a side tumbler, of which there are two, the full skips pushing the empty one off at the other end. The coal falls into a shaking screen made of four plates, in which there are oblong holes. The large coal falls on to a picking belt, and then down a shoot into waggons. The shoot has a swing door, which is let down while filling the waggons; this not only bridges the space between the shoot and the waggon, but does away with the necessity of stopping the picking belt while changing waggons. The slack falls into a small coal hopper, from which it is elevated along a trough to a slack box. Out of this box the fuel for the boilers is drawn, and the miners get their monthly allowance of one ton per man. There is a slide door at the bottom of the trough, where it passes over a line of rails, so that waggons can be loaded with slack as required. Any dirt brought out of the mine is tipped into a dirt box from an end tippler. The side tumblers are set in motion by a man who, by pressing on a lever with his foot, forces a revolving pulley against the rim of the tumbler.

The boiler house contains four Lancashire boilers; they are 30ft. long, and each tube is 3ft. 3in. in diameter. The boilers are made for a working pressure of 120lbs. of steam, and are each rated at 300 h.p. Two of the boilers were made by Goninan and Co., and two by J. Thompson, of Wolverhampton. Arrangements are made whereby the dampers can be manipulated from the front of the boilers. The water is fed in by two Smith, Vaile pumps.

The power-house encloses two sets of Bellis-Morcom high speed engines, each direct coupled to a 100k.w. British Thompson Houston 6 pole, 250 volt generator.

A stump cabin has been erected by the company, in which the men can pay their dues to an officer of their union.

CHAPTER XVI.

General Remarks.

There has been no systematic sampling of the various coal seams in the different collieries. Analysis have been made and published, which have been obtained from various sources, interested and otherwise. Until this matter is taken in hand and properly carried out by some independent person, the comparison of Australian coals with those of other countries must be accepted as approximate only. The following are the results of samples taken and analysed by representatives of the Department of Mines, N.S.W.:—

Proximate analysis of coals from collieries of the Western Coalfield. These coals are all from the Upper Coal Measures.

Name of Colliery.	Hygroscopic Moisture.	Volatile Hydrocarbons.	Fixed Carbon.	Ash.	Sulphur.	Specific Gravity.	Coke.	Lb. of water converted into steam by 1lb. of the coal.
[1]Ivanhoe Colliery, Piper's Flat (a)	3.95	26.11	56.01	13.93	0.580	1.400	—	11.2
[1]Irondale Colliery, Piper's Flat (b).. ..	3.95	26.17	55.25	14.63	0.590	1.508	—	11.4
[1]Cullen Bullen (c).. ..	1.25	34.15	51.95	12.65	0.645	1.348	64.60	12.1
[1]Lithgow Valley Colliery, Lithgow (d) ..	2.25	33.20	53.35	11.20	0.713	1.358	—	12.1
[2]Eskbank Colliery, Lithgow (e)	1.07	33.38	52.80	12.75	0.370	1.366	65.55	12.1
[1]Cobar Copper Works Colliery, Lithgow (f)	1.95	30.50	51.65	15.90	0.590	1.422	—	11.3
[1]Zig Zag Colliery, Lithgow (g)	0.95	34.35	52.55	12.15	0.576	1.360	64.70	12.1
[1]Vale of Clwydd Colliery, Lithgow (h)..	0.90	34.75	51.15	13.20	0.576	1.357	64.35	11.8
[1]Oakey Park Colliery, Lithgow (i)	1.90	33.80	53.15	11.15	0.830	1.278	64.30	12.6
[2]Portland Colliery (j)	6.06	20.26	50.70	13.98	0.672	1.432	—	—
[2]Hermitage Colliery, Lithgow (k)..	2.26	28.01	57.23	12.5	0.603	1.417	—	—

Remarks.—(*a*) No true coke formed, mass fritted together, dull lustre, ash nearly white, granular. (*b*) No true coke formed, mass fritted together, dull lustre, ash nearly white, granular. (*c*) Coke not much swollen, fairly bright, firm, covered with cauliflower-like excrescences, ash white, granular, with some flocculent patches. (*d*) No coke formed, only a well fritted cake left after ignition, ash reddish tint, part granular, part flocculent. (*e*) Coke very little swollen, bright and firm, ash very light grey, granular. (*f*) No coke formed, only a partially fritted cake left after ignition, ash almost white, granular. (*g*) Coke fairly swollen, firm and lustrous, numerous cauliflower-like excrescences, ash white, granular. (*h*) Coke slightly swollen, firm and lustrous, some cauliflower-like excrescences, ash very light grey, granular. (*i*) Coke fairly swollen, lustrous and firm, numerous cauliflower-like excrescences, ash, white, granular. (*j*) No true coke, ash nearly white, granular. (*k*) No true coke, ash white, semi-granular.

[1]The samples were taken in 1899 by the then mine inspectors, and assayed in the laboratory of the Department of Mines. See E. F. Pittman. "The Mineral Resources of New South Wales," 1901, Sydney. By authority.

[2]Assayed by W. A. Greig, and quoted by J. E. Carne in his "Geology and Mineral Resources of the Western Coalfield." By authority. Sydney, 1908.

Proximate analysis of coals from collieries of the Southern Coalfield. These coals are all from the Upper Coal Measures.

Name of Colliery.	Hygroscopic Moisture.	Volatile Hydrocarbons.	Fixed Carbon.	Ash.	Sulphur.	Specific Gravity.	Coke.	Lb. of water converted into steam by 1lb. of the coal.
[2]Sydney Harbour Colliery, Balmain, 2nd Cremorne Bore (*a*)..	0.66	17.57	71.09	10.68	0.724	1.346	81.77	13.0
[1 3]Metropolitan Colliery, Helensburgh (*b*) ..	1.27	18.40	70.56	9.76	0.384	1.402	80.32	12.8
[1 3]Coalcliff Colliery, Clifton (*c*)	0.82	21.57	64.30	12.80	0.301	1.341	77.60	12.5
[1 3]South Clifton Colliery, Scarborough (*d*) ..	0.96	22.68	66.87	9.47	0.420	1.383	76.35	12.6
[1 3]Bulli Colliery, Bulli (*e*)	0.78	23.79	64.96	10.51	0.665	1.402	75.61	13.2
[1 3]South Bulli Colliery, Bellambi (*f*)	0.96	22.68	66.87	9.47	0.420	1.383	76.35	12.6
[1 3]Bellambi Colliery, Bellambi (*g*)	0.78	24.30	64.43	10.48	0.599	1.388	74.86	13.0
[1 3]Corrimal Colliery, Corrimal, (*h*)..	1.13	24.79	64.80	9.27	0.320	1.385	74.07	12.8
[1 3]Mount Pleasant Colliery, Wollongong (*i*)	0.95	24.00	65.55	9.49	0.355	1.378	75.04	13.0
[1 3]Osborne-Wallsend Colliery, Mt. Keira, Wollongong (*j*) ..	0.93	24.24	65.06	9.75	0.466	1.372	74.82	13.0

Remarks.—(*a*) Coke fairly swollen, firm, dull lustre. (*b*) Coke not much swollen, dull lustre and fairly brittle, ash slightly reddish tinge, granular. (*c*) Coke well swollen, with slight cauliflower-like excrescences, firm and lustrous, ash grey, flocculent. (*d*) Coke well swollen, bright and firm, ash slight reddish tinge, flocculent. (*e*) Coke well swollen, with slight cauliflower-like excrescences, firm and lustrous, ash grey, flocculent. (*f*) Coke well swollen, with cauliflower-like excrescences, firm and lustrous, ash yellowish tinge, flocculent. (*g*) Coke well swollen, firm and lustrous, ash grey, flocculent. (*h*) Coke well swollen, bright and firm, ash almost white, flocculent. (*i*) Coke fairly well swollen, firm and lustrous, ash grey, granular. (*j*) Coke well swollen, with slight cauliflower-like excrescences, firm and fairly lustrous, ash grey, flocculent.

[1]The samples were taken in 1899 by the then mine inspectors, and assayed in the laboratory of the Department of Mines. See E. F. Pittman. "The Mineral Resources of New South Wales," 1901, Sydney. By authority.

[2]Assayed by W. A. Greig, quoted by J. E. Carne in his "Geology and Mineral Resources of the Western Coalfield." By authority. Sydney, 1908.
[3]Mean of two analysis.

Proximate analysis of coals from collieries of the Northern Coalfields.

Name of Colliery.	Hygroscopic Moisture.	Volatile Hydrocarbons.	Fixed Carbon.	Ash.	Sulphur.	Specific Gravity.	Coke.	Lb. of water converted into steam by 1lb. of the coal.
[1,3]Wallarah, Swansea (*a*)	0.97	32.67	57.45	8.90	0.322	1.383	—	12.3
[1,3]Pacific, Teralba (*b*) ..	3.21	32.06	52.25	12.47	0.422	1.405	64.72	11.8
[1,3]Northern Extended, Teralba (*c*)	2.05	32.53	53.69	11.72	0.343	1.399	65.41	12.1
[1,3]Northumberland, Fassifern (*d*)	2.54	30.54	50.69	16.22	0.452	1.412	—	11.4
[1,3]Maryland, Plattsburgh (*e*)	2.25	35.70	57.25	4.80	0.624	1.296	62.05	13.5
[1,3]Co-operative, Newcastle (*f*)	1.70	35.37	54.61	8.31	0.535	1.321	62.92	13.1
[1,3]Waratah, Charlestown (*g*)	1.87	32.87	55.55	9.70	0.446	1.346	65.25	12.6
[1,3]Duckenfield, Newcastle (*h*)	2.30	34.61	52.95	10.13	0.560	1.314	63.08	12.45
[1,3]Seaham, West Wallsend (*i*)	2.20	35.81	53.97	8.02	0.405	1.324	61.99	12.4
[1,3]West Wallsend, Charlestown (*j*) ..	1.57	35.82	53.55	9.05	0.534	1.365	62.60	18.6
[1,3]Killingworth, Cockle Creek (*k*)	2.09	35.43	52.78	9.56	0.405	1.315	62.39	13.1
[1,3]Newcastle A and B, Newcastle (*l*)	1.22	37.55	55.20	6.02	0.439	1.308	61.22	13.0
[1,3]A. A. Co.'s New Winning, Newcastle (*m*)	1.64	37.38	55.05	5.93	0.418	1.297	60.98	13.6
[3]Hetton, Bullock Island, Newcastle (*n*)	1.91	37.41	54.03	6.65	0.431	1.252	60.68	13.5
[1,3]Dudley, Dudley (*o*)..	.78	37.39	53.05	8.77	0.281	1.332	61.82	12.45
[1,3]Burwood, Lambton (*p*)	1.80	36.20	55.20	6.80	0.424	1.309	62.0	13.2
[1,3]Lambton B. Durham (*q*)	1.72	33.62	55.47	9.17	0.487	1.344	64.65	12.7
[1,3]Greta Colliery (*r*) ..	1.50	40.62	49.93	7.9	1.87	1.302	57.83	13.6
[1,3]East Greta (*s*)	1.76	40.45	52.25	5.53	1.05	1.284	57.78	13.7
[4]Heddon Greta (*t*) ..	2.11	39.59	54.99	3.31	—	1.275	58.30	—
[4]Stanford Merthyr (*u*) ..	2.21	40.76	50.95	6.08	0.26	1.288	57.03	—

Remarks.—(*a*) No coke formed, only a dull, loosely-coherent cake left after ignition, ash yellowish, flocculent, part granular. (*b*) Coke well swollen, fairly firm and lustrous, ash grey, granular. (*c*) Coke not much swollen, brittle and dull, ash reddish tinge, granular. (*d*) No true coke formed, ash gray, flocculent. (*e*) Coke well swollen, firm and lustrous, ash reddish tinge, flocculent. (*f*) Coke well swollen, with cauliflower-like excrescences, firm and lustrous, ash reddish tinge, granular. (*g*) Coke well swollen and firm, ash brownish, flocculent. (*h*) Coke well swollen, with cauliflower-like excrescences, firm and lustrous, ash reddish tinge, granular. (*i*) Coke well swollen, firm and lustrous, ash reddish tinge, granular. (*j*) Coke moderately swollen, bright in patches, firm, ash reddish, granular. (*k*) Coke excellent, well swollen, with cauliflower-like excrescences, firm and lustrous, ash grey in colour, flocculent or granular. (*l*) Coke well swollen, hard and bright, ash brownish, part granular, part flocculent. (*m*) Coke well swollen, with cauliflower-like excrescences, firm and lustrous, ash reddish tinge, granular. (*n*) Excellent coke, well swollen, with cauliflower-like excrescences, firm and lustrous, ash slight reddish tinge, part granular. part flocculent. (*o*) Coke well swollen, bright, with dark patches, ash reddish, granular, some portions flocculent. (*p*) Coke well swollen, hard and bright, ash brownish, granular. (*q*) Coke fairly swollen, firm, ash light brown, flocculent. (*r*) Coke well swollen, firm and lustrous, ash grey, granular. (*s*) Coke well swollen, with cauliflower-like excrsecences, firm and lustrous, ash slight reddish tinge, granular. (*t*) Coke fairly lustrous and well swollen, with cauliflower-like exrescences, ash light pink colour. (*u*) Coke firm, bright, fairly well swollen, ash grey.

[1]The samples were taken in 1899 by the then mine inspectors, and assayed in the laboratory of the Department of Mines. See E. F. Pittman. "The Mineral Resources of New South Wales," 1901, Sydney. By authority.

[3]Mean of two samples.

[4]Prof. T. W. E. David, "The Geology of the Hunter River Coal Measures, New South Wales," 1907, Sydney. By authority.

Many of our older collieries are equipped with old-fashioned machinery, which was good enough when first installed, but which is now out of date. Such collieries being nearly worked out, it would not pay to replace the existing machinery with that of a more modern design, in spite of the fact that the latter may do more effective work, and cost less for upkeep. On the other hand, some proprietors have thought to economise by removing old-fashioned machinery from a defunct colliery to a younger one, forgetting that although the wheels can turn round, they may consume more power in turning than modern practice permits. Keen competition at the present day obliges one to look into small matters of economy which, by accumulation, amount to a large figure by the end of the year; thus the fact is forced on steam users that it is cheaper to provide suitable feed water for boilers than to execute repairs. Taking our collieries on the whole, however, they compare very well with those in other parts of the world, and some of our colliery managers who have travelled in Europe and America in recent years are satisfied that, so far as methods and equipments are concerned, Australian collieries are not behind hand. Improvements are constantly being made, for a colliery of any extent will generally stand the expense of improvements so as to enable it the better to compete with others in the trade. In cases, better sites might have been selected for surface works, better grades for self-acting inclines adopted, and other alternatives might have been made with advantage; but such initial errors common to all mining districts are gradually being rectified.

There are dangers peculiar to all industries, and coal mining is no exception. Inrushes from the sea have to be guarded against in some of the coastal collieries, while measures have to be taken to prevent spontaneous combustion and explosions of fire damp and coal dust in others.

Mechanical difficulties, such as sinking through quicksand, have been met with and overcome in certain instances.

Our coal trade is still hampered at times for lack of sufficient rolling stock and for want of better loading appliances at wharves.

We have heard a good deal lately about the necessity of having breathing apparatus installed at collieries, so as to enable men to penetrate poisonous gases. With the exception of one or two outfits of an ancient type at Messrs. J. and A. Brown's collieries, I have been unable to learn that any such apparatus are kept on our coalfields, and if they were, they would be no good without a corps of men trained in their use. Some different types have been brought out to Australia by agents, and have been officially tested, but did not give satisfaction. After the Courrieres disaster in France, breathing apparatus were

used; they were not the means of saving any life; on the contrary, some of the rescue party lost their lives. A Royal Commission was appointed in England to enquire into certain matters connected with the safety of mines, and, among other things, went into the question of breathing apparatus. In their first report, issued in 1907, the commissioners came to the conclusion that there was not really any thoroughly suitable breathing apparatus so far brought to their notice, though some of them were considered capable of being made effective. They classified existing forms of breathing appliances into one of the following four types:—

"(i.) The first and simplest consists of a helmet through which a constant current of air is driven from a pump or compressed air pipe connected with the helmet by a long length of hose. This form of apparatus, which is similar in principle to the ordinary diver's helmet, is very useful when the wearer has only a short distance to go from the fresh air supply, as for instance, in many operations connected with underground fires, but would evidently be of little use in rescue work after explosions. About two cubic feet of air per minute are required during work."

"(ii.) In the second type (including the "Shamrock," "Improved Fleuss," "Draeger," "Weg," and other apparatus), the wearer breathes into and out of a bag provided with such arrangements that the carbon dioxide in the expired air is absorbed, and that highly-compressed oxygen from a steel cylinder replaces that which is absorbed by the wearer. In the three first-mentioned appliances the rate of supply of oxygen from the cylinder is constant, and equal to about the maximum rate of consumption during hard work. This affords a certainty of there being sufficient oxygen at all times, but necessitates much waste. In the "Weg" apparatus there is an ingenious contrivance by which the rate of supply of oxygen adapts itself to the rate of consumption, so that waste is avoided."

"(iii.) In the third type ("Pneumatogen" apparatus) the expired air is passed through a cylinder containing superoxide of sodium and potassium. This not only absorbs the carbon dioxide, but also liberates at the same time sufficient oxygen to make up what has been absorbed by the wearer. This apparatus is much lighter than the others, and thus presents obvious advantages. Unfortunately, however, some serious attendant disadvantages have not as yet been overcome."

"(iv.) In the fourth type ("Aerolith" apparatus), the wearer is afforded a supply of air by the evaporation of "liquid air." The apparatus is light and comfortable, but its use would entail arrangements for making liquid air and maintaining a constant supply to each place where the apparatus was

stored." A man at rest uses about 0.3 litre of oxygen per minute, while severe exertion raises the consumption to 2 litres per minutes.

The greatest drawback to the Australian coal mining industry is the constant labour unrest, generally culminating in strikes of one or other of the various unions into which the colliery employees combine. Men connected with coal mining seem peculiarily susceptible to strikes, they are utterly callous as to how their actions inconvenience the public and the country, and yet they appeal to the public for assistance. Coal miners are far better paid than metal miners for the work they do, but as the state of trade does not permit them to work full time, they do not make so much for the year. Not being business men, colliers believe those agitators who tell them that if the masters liked to demand more for their coal, they would be in a position to pay better wages. To a certain extent that might hold good for the home market, though then manufacturers would have to charge more for the articles that they produced with the expensive fuel, which in turn would reflect on the colliers, so that when all is said and done, if the workers do receive a higher rate of pay than in other countries, the purchasing power of that money will be less in Australia, so in the long run the workers are no better off; on the contrary, they are worse off, for, with such high rates, they connot hope to compete successfully with other countries. But there is a limit to all things, and if the price of coal and coke is too high, these articles will be imported into Australia from abroad, which indeed has already been done. By forcing up the price of coal, New South Wales has indirectly assisted the coal mining industry of other places. Near at hand, in Victoria, the State has started a coal mine to supply its wants, and, in consequence, New South Wales has lost that market. Rather than be dependent on the vagaries of the coal miners in New South Wales, the Western Australia Government support the Collie coalfield. Recent strikes have given a fillip to coal mining in New Zealand. But, in addition to this loss in the home trade, the export trade has also suffered, for our industrial troubles have helped on outside competitors, who have not only secured fresh trade, but have captured some of our markets; and every man knows it is easier to keep a customer than to obtain a new one. The total output of coal in New South Wales for the year 1909 was 7,019,879 tons, valued at £2,618,596, being 2,127,146 tons, worth £734,497, less than the previous year. Of the above tonnage, 4,393,603 tons, valued at £2,234,117, was exported, as against 6,098,676 tons, valued at £3,021,021, in 1908, showing a decrease of 1,705,073 tons and £786,904 in value. This fall off was mainly due to the general strike of coal miners. Some of the trade may be won

back, but it is feared that most of it has been lost to Japan, British India, China, Borneo, United States and Great Britain, who now supply customers in the Philippines, Straits Settlements, Java, India, Hongkong and South America, formerly supplied by New South Wales. Co-operation has been tried among miners, but collieries run on this principle have not proved a success. Even State-owned mines have not been proof against labour trouble, as witness those of Victoria and New Zealand.

The over-sea trade is governed by conditions over which Australians have no control. Ships can go to any part of the world for freights, and at certain seasons of the year the demand causes freights to go up, and an extra shilling per ton may lose a coal contract to another country working under more favourable conditions. Besides, foreign countries take such a serious view of our labour troubles that they look elsewhere for their coal supplies, which, if not so good, are at least reliable. Then again, shippers do not care to charter ships for Newcastle, not knowing how long they may be laid up on account of some frivolous strike.

Strikes, by restricting the coal trade, lessens the demand, make less work for the coal miner and those dependent on him; hence the broken time worked. If the miner likes to limit his earning capacity, that is largely his own affair, though indirectly it also affects the welfare of the country, but unfortunately there are many strikes, several of them being of a trivial nature, run by mere boys, which affect others, such as those who handle coal, tradespeople, etc., to say nothing of diminishing railway profits, laying other industries idle for a time, and throwing fellow unionists out of work. It is to be hoped that the miners and others concerned in the coal industry will learn to think and speak for themselves before the industry is ruined, instead of allowing themselves to be led by irresponsible and ignorant agitators. There are two sides to every question, and each should be treated with respect. There are many things one would like to happen, but they may not be feasible. Miners would naturally like higher wages, but if the higher wages killed the industry, the temporary advancement would be a permanent injury; or a curtailment of the output might increase the earnings of a few while throwing a large number of their fellow men out of work. Nature seems to have been generous to New South Wales so far as coal and seaboard are concerned; it is the unreasonable action of man that prevents full advantage being taken of what is offered.

CHAPTER XVII.

History of Victorian State Coal Mines.

By Geo. H. Broome (General Manager).

The Mines are situated about 86 miles south-east from Melbourne, and three miles from Cape Paterson in what is known as the Powlett basin.

In Victoria black coal has, so far, only been found in rocks of Jurassic age. These rocks are usually some thousands of feet in thickness, and although a number of deep bores have been put down, it is only in the neighbourhood of Wonthaggi that the underlying rock has been reached.

Although the Jurassic rocks extend over an area of about 5500 square miles, of which about 2200 square miles are exposed at the surface, nearly all the localities where payable black coal occurs may be found in an area about 50 miles long by about 10 miles wide, running north-easterly from the mouth of the Powlett River to Moe.

At the south-eastern end of this area is situated the Powlett Basin and in it the State Mine Reservation, which consists of an area of approximately 15 square miles in the parish of Wonthaggi, while adjoining it on the east is the Kirrak Basin, which is at present withheld from mining leases.

On the State Mine Reservation about 22,000,000 tons of payable coal have already been proved to exist in seams ranging from 2ft. 6in. to 10ft. in thickness, and boring is still in progress to ascertain the extent of the field.

The Jurassic rocks consist of sandstones, mudstone and false bedded sandy shales, leaf impressions being abundant and marine fossils entirely absent.

The coal, which is usually laminated, always rests on a mudstone floor.

Any coal at a depth of less than 50ft. is usually very friable, but all coal beyond that depth is much firmer, although boring shows that it is not correct to assume that the greater the depth the better quality of coal.

Three bores have gone down 1158ft., 2633ft., and 1380ft. respectively in search of lower seams, but without meeting anything of a payable nature.

The coal-bearing rocks throughout the State Mine area are marked by recent deposits of sands and clays, seldom exceeding 30ft. in thickness. The surface consists largely of dunes of blown sand and swamps, in which peat deposits are now accumulating. From a study of the boring records it appears that the present surface deposits now being formed are of a somewhat similar character to some of those that were deposited contemporaneously with the Wonthaggi coal seams.

The most important geological features from a mining standpoint are the faults or vertical displacements that occur throughout the Victorian coal measures. These faults may vary considerably in displacement, sometimes dying out to nothing at one or both ends, while the maximum vertical displacement often exceeds 100ft., and in the main fault lines considerably more. As far as the present workings are concerned it has been found that the faults usually run approximately at right angles following the cardinal points of the compass. These faults have the effect of cutting the coal area into a series of plateaux.

Boring has been done at fairly close intervals ahead of the State Mine workings, and the data obtained has been utilised in constructing a model showing the lie of the coal. By this means shaft sites can be selected and an idea formed in advance of how the workings should be laid out. Over the ground worked to date it has been found that the general rule is that the coal dips to the south, and when faults occur is down thrown to the north, making a section resembling a saw tooth. These faults act as natural boundaries to the area of coal that can be profitably worked from each shaft, and as the deepest coal yet found on the State Mine Reserve is only at a depth of 500ft., shaft sinking is not a serious item, and it is expected that by selecting shaft sites in suitable positions, dead work will be reduced to a minimum.

The fault movements appear to be still in progress, and can often be picked up on the surface, thus affording valuable data for prospecting work.

Analysis of the Coal.

The following are the results of samples obtained and analysed by the New South Wales Department of Mines:—

Sample.	Moisture.	Vol. H.C.	Fixed Carb.	Ash.
No. 1	4.42	34.80	51.36	9.42
No. 2	4.81	34.94	51.52	8.73
No. 3	5.57	33.22	51.40	9.81

Sample.	Sulphur.	B.T.U.'s.	Specific Gravity.	Coke. per cent.
No. 1	.811	11,810	1.317	60.78
No. 2	.597	12,310	1.323	60.25
No. 3	.489	11,810	1.375	61.21

A few words in connection with the birth of the Victorian State Coal Mines might be interesting. During the month of November, 1909, the whole of the New South Wales coal miners came out on strike, and as the strike seemed likely to continue for some considerable time, the Minister of Mines, the Hon. Peter McBride, with commendable promptitude, called for reports from various officers of his department as to how soon shafts could be sunk, coal mined, despatched to Inverloch by bullock waggon, and shipped to Melbourne. From four to five weeks was given as the time that the above work could be accomplished, and the following officers were ordered by the Minister to immediately start for the Powlett, and proceed with the work:—Mr. Stanley Hunter, M.I.M.E., and Mr. D. C. MacKenzie, M.E., in charge of the work generally; Mr. Geo. Falloon, as secretary, and in charge of accounts and timesheets. These officers were ably assisted by the sterling sevices of Messrs. D. H. Browne and J. MacKenzie, two veteran mine managers of varied experience and tried ability.

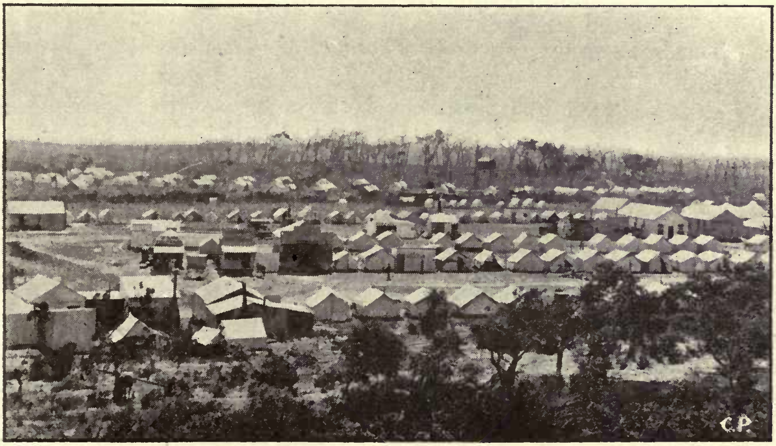
Work was seriously commenced on the 22nd November, 1909. Three shafts were sunk in close proximity to an old prospecting shaft on a shallow area of coal in Allot. 26.

Four of the drills working on the field were brought to the shafts, and erected one over each shaft. These were ingeniously converted into winding and pumping plants, and were successful in raising 43,000 tons of coal in baskets before a steam winding-plant was installed. Oil engines were used to drive the converted drills.

In working the emergency mine, the coal was filled at the face into baskets holding 2 cwt. A trolley holding two baskets brought the coal to the various shafts, where it was hauled to the surface, placed on another trolley, and wheeled out to the dumps. The gauge of the trolley roads was 18in.

Owing to the isolation of the field from railways and good roads, it was only by the adoption of this primitive method that the phenomenal development of the mines was made possible.

To accommodate the workmen during the emergency period "Canvas Town" had to be erected. The tents were strongly built, and laid out in surveyed rows, with formed streets, strict attention being paid to drainage, and other sanitary conditions. Business people were supplied with sites on entering into a guarantee to faithfully comply with the strict sanitary laws laid down for the government of "Canvas Town." A reticulated water service was laid down, the water being pumped from a swamp near the coast, through about two miles of pipes. A double-pan sanitary service was also introduced, and it speaks well for the whole arrangements that during the hot summer of 1910 not one case of fever had to be dealt with.



Powlett River Camp, February, 1910.

Ten thousand tons of coal were dumped at grass, and 5000 tons were despatched by bullock waggon, by the time the railway connection with Nyora reached the mines, 10 weeks, a railway from Nyora to the coalfield, 27 miles in length, having been constructed by the Railway Department in this time.

It is interesting to note that all through this period of emergency mining, when hustle and bustle were the order of the day, no serious accident of any kind occurred, which, considering that the roof in the shallow area was a very soft and tender one, was a very creditable result.

The method of working adopted during this period was stoop-and-room, the pillars or stoops being about 100ft. square and the roadways 10ft. wide.

During the rush of emergency mining, great care was exercised in the timbering methods adopted.

In the south side workings, where the cover was from 30 to 40ft., only 6ft. of the coal seam was mined, the remaining 2ft. being kept on for a roof, as it was found to have more bind than the decomposed strata above it.

Split bars, 9in. x 7in. section, were put up to the coal roof on legs of 8in. x 6in. section. The bar sets would average about 4ft. centres, and where necessary were laced with slabs. In the deeper workings in the north side, all the coal in the first workings was taken out to a fair sandstone roof, which was then timbered with the same care as in the south side. In the present workings, especially in No. 5 main shaft, the ordinary coal mine method of timbering with "prop and lid" is usually found sufficient in the 15ft. bords.

The maximum output reached during the emergency period was 400 tons per day.

Ventilation was chiefly natural, assisted by Root's blowers.

All labour was paid by the day, according to the following scale:—

Coal miners, 10s. per day.
Hand wheelers, 6s. to 8s. per day.
Winch drivers, 8s. 4d. per day.
Deputies, 11s. per day.
Skilled labourers, 7s. 6d. to 9s. per day.
Unskilled labourers, 7s. 6d. per day.

When the Government succeeded in getting their State Coal Mines Bill through, arrangements were made to equip the mines in accordance with modern principles, and No. 3 shaft was made ready for winding. A pair of coupled horizontal engines, with 14in. cylinders, were placed in position on good concrete foundations.

Poppet legs, about 70ft. in height, were raised over No. 3 shaft, and in June of 1910, the old basket system was superseded by the more modern method of winding with cages.

The tipple at this shaft is equipped with modern appliances, so as to reduce as far as possible the cost of handling the coal.

These include a patent two-speed tippler (the invention of the writer, who took charge of the operations in April, 1910), and a modern screening and conveyor plant. The tippler works excellently, and is most adaptable for dealing with soft coals. A lever is touched to start the tippler, and the tippler

does the rest. The first portion of the revolution, until the coal is emptied out, is very slow; the speed for the remainder of the revolution is much faster. The tippler comes automatically to rest in a position to receive the next skip, when the cycle is repeated.

The time taken for a complete revolution is 13 seconds. The coal is passed over jigging screens and a jigging chute, and is effectively screened and picked before it reaches the railway trucks.

This description of No. 3 main shaft would not be complete without reference to the excellent accommodation for the miners, in the way of change-rooms, bath-rooms, and drying-rooms.

The change-rooms are six in number, and are so arranged that four are always locked, and only those two in connection with the shift coming off are open. Pilfering is thus reduced to a minimum. The bath-rooms are fitted with plunge baths, shower baths, and wash basins. The floor is of concrete, and an ample supply of hot and cold water is provided. The drying-room is divided into three compartments, one for each shift, separated from each other by trellis work. Four-inch diameter steam pipes are arranged in four horizontal rows in each compartment, and the miners are always sure of dry clothes to go to work in. An average of 640 miners use the above arrangements daily.

In addition to No. 3 main shaft, there is another main shaft, No. 5, the workings from which have developed up to 1000 tons per day. At present, old-fashioned gravity screens are being used for screening, but the erection of a modern self-acting tippler is being urged, and this would compare favourably with anything of its kind in Australasia. Steel hopper bins, with a total capacity of 1000 tons, are being erected as an adjunct to the tippler.

The shaft is 150ft. deep, 19½ft. long, and 15½ft. wide. Two skips side by side are put on each cage.

The pit bottom arrangements in this shaft are such that the loaded skips are put on the cages on one side of the shaft only, the empties all being taken off from the other side.

The coal is brought to the shaft bottom by a "main and tail rope haulage," and a self-acting incline; 20 skips form a rake on the former, and 12 on the latter.

Near No. 5 shaft is situated No. 6, which is used for pumping, lowering timber and ventilation. The pumping plant consists of 16in. horizontal engine, with pumping gear, all set on massive concrete foundations.

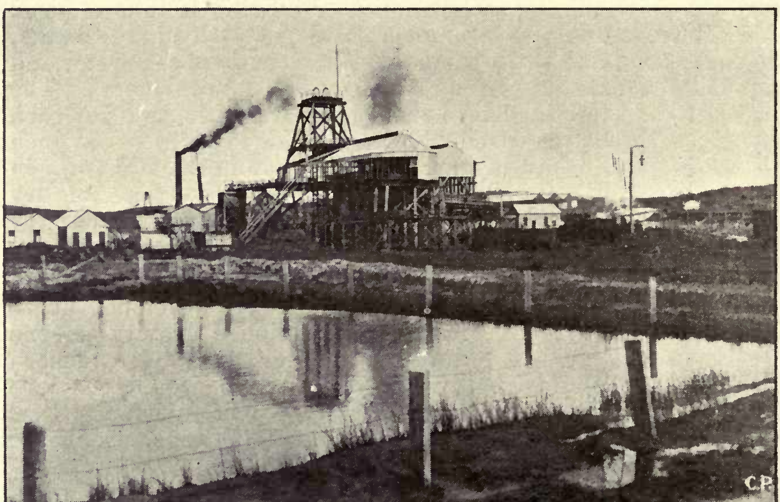
This plant works an 8in. Cornish lift of pumps on a 6ft. stroke. The plant is much ahead of present requirements, but is calculated to deal with any unexpected inrush of water.

A Cornish boiler, 30ft. long, and 6½ft. in diameter, supplies steam for the pumping plant.

Nos. 3 and 5 main shafts are so far the two principle winding shafts, and are dealing with the present output of 2000 tons per day.

Two shafts, Nos. 9 and 10, are now being sunk. They will be about 300ft. in depth when completed, and will jointly tap an area estimated to contain 4½ millions tons of coal.

These shafts are 14½ft. by 12ft. in the clear, and will be fitted up with cages holding two skips set tandem. As it is anticipated that heavy surface water from the surrounding



State Coal Mine, Powlett River.

swamps may ultimately find its way into the underground workings, that contingency has been guarded against by installing a heavy set of Cornish pumps, capable of dealing with 500,000 gallons of water per day.

The pumping gear and bob are set on massive concrete foundations, and connected to a 22in. cylinder engine having a 5ft. stroke.

A surface haulage worked by endless rope is now being laid down to connect these shafts with No. 5 shaft, where all the coal will be screened.

The coal operated on so far averages about 6ft. thick, and bord and pillar (modified) is the system of working adopted, with the exception of one section, which is being prepared for longwall machine-mining.

Nos. 3 and 5 shafts are ventilated by means of a "Capel" centrifugal fan (double inlet), 8ft. in diameter, capable of passing 180,000 cubic feet of air per minute with a W.G. of 3in.

The men and ponies travel in and out of the mines by means of a crosscut drive, which has been cut through to the surface. This is a decided advantage, as the ponies can all be stabled on the surface. The stables are of most modern design, and are capable of housing 150 ponies. The washing and hosing down shed extends the whole length of the buildings. The cost of feeding, including draught horses and hacks, runs out at 5s. 5d. per head per week.

A complete fire service, with hose stations, has been laid down over the whole of the timber yard, and surface works. One of the fitters, with good brigade experience, spends part of his time in schooling a mine brigade, and attending to the various reels and hydrants.

The temporary backsmith shop is furnished with six forges, and turns out all the work necessary for the efficient working of the mine.

Adjacent to the smithshop, there is a temporary plumbers' shop and saw bench, both of which have been useful factors in the quick development of the mines.

A brief description of the method of time-keeping and allocation of expenditure might be interesting. A numbered token is handed to each workman on going to work, and returned by him when his shift is finished. Those men who are not exclusively employed on one job, hand in a daily time-card, showing the time employed on each branch of the work. The accuracy of the records in the underground deputies and surface foreman's books is checked by means of the time tokens issued. From the deputies' time books, and the daily time-cards, a dissection of wages expenditure is made daily, and shown on a "Daily Labour Cost" return. This, in common with all the revenue returns, shows the cost, per ton, of coal, under each sub-division of the expenditure. The totals of the daily cost sheets give the fortnightly wages total.

All stores purchased are debited to Stores Account, and issued on requisitions signed by foremen and other authorised persons. The mine's accountant is advised fortnightly by the

storeman of the total amount of stores issued under each expenditure heading. All expenditure is collected in the ledger, and elaborate fortnightly returns are compiled.

Expenditure on capital and revenue is carefully distinguished, the capital returns showing the progressive cost of each work, until completion.

The quick development at the State coal mines constitutes a world's record in coal mining. The mines are now capable of producing over 2000 tons of coal per day. Up to the 30th June, 1911, the total output of coal raised was 452,000 tons, and the aggregate total of distances driven in coal drives and stone drives was 27.278 miles.

The total footage sunk up to the same date was:—

Main shafts	1216	feet
Timber and air shafts	120	,,
Total	1336	,,

The capital expenditure to date is only £89,000, to which, however, must be added £35,000 for contracts in progress.

In keeping with the record development of the mines is the wonderful progress of the town of Wonthaggi. The town with its suburbs is estimated to contain a population of 8000, and ranks next to Geelong in Victorian towns for size.

It is beautifully laid out, and when the roads are finally metalled, and the young trees, which are looking very healthy at present, have had time to grow, it will be a very agreeable place to live in. The residential portion of the town is away from the business portion. This is a new departure from the system adopted in laying out most Victorian towns. The water scheme is most comprehensive, and assures a plentiful supply of water for years to come. The water gravitates from the large dam at Lance Creek, to a storage reservoir on the top of McLeod's Hill, in Wonthaggi. From this storage reservoir the water is reticulated over the lower portions of the town. A steel storage reservoir is now being erected to provide a sufficient pressure to reticulate the higher portions of the town. The whole scheme cost £60,000, and was carried out under the direction of Messrs. J. M. and H. E. Coane, consulting engineers, of Melbourne.

Spread over the residential portion of the town, and adding greatly to the beauty thereof, stand 100 Government cottages. These cottages were built for the convenience of the miners, and cost over £20,000. Each cottage stands in a ¼-acre allotment, and is substantially built of hardwood, with plastered walls inside to a dado of alternate strips of white and red pine. The cottages were designed by Mr. Stanley

Hunter, and are of three classes, to suit the varying requirements of the miners. A feature of each cottage is a bathroom, which, to a coal miner, is a most desirable comfort.

This article would not be complete without a reference to the State brick works.

They are situated about $\frac{1}{4}$-mile from Nos. 9 and 10 shafts.

The brick-making machinery consists of one wire-cut machine, one grinding mill, and two dry press machines, each capable of turning out 1200 bricks per hour. At present the output of bricks per week is 100,000, most of which are being used in building a modern Hoffman kiln.

A steam-driven electric power plant is now being installed at the mine, with the object of supplying power for winding and surface work at Nos. 9 and 10 shafts, and at any future shafts that may be sunk, also for underground pumping, hauling, ventilation, coal-cutting, lighting, etc., at all the shafts. It is also proposed to supply light and power to the township of Wonthaggi.

The generating plant will consist of two Browett-Lindley three-cylinder high-speed vertical engines, of 750h.p., direct-connected to two three-phase 5200-volt 50-cycle 500kw. generator of British Thomson-Houston manufacture, and one exhaust steam mixed pressure turbine of 520kw. capacity. A surface condensor with a capacity to handle the total steam required for the generator of 2000h.p. will be situated immediately under the turbine.

The steam for this plant will be supplied at a pressure of 150 lbs. per square inch from eight Lancashire boilers, with a total output capacity of 2800h.p. The boilers will be fitted with Perks Dane underfeed stokers and forced draught will be employed.

The contractors for the electrical plant are the Australian General Electric Company, and for the boiler plant Messrs. Thompson and Co., engineers, of Castlemaine.

A workshop, comprising smith's shop, machine shop, and carpenter's shop, has been erected adjacent to the power house, and the following equipment is being installed:—

In the smith's shop: Shears and punch, pneumatic hammer and wheel press.

In the machine shop: Screw-cutting lathes, screwing machines, radial drill, shaping machine, jig saw, etc.

In the carpenter's shop: A band saw, mortising machine, multiple wood-boring machine, etc.

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Y

GLOSSARY.

After damp.—The mixture of gases left after a colliery explosion, consisting of carbon dioxide, carbon monoxide, nitrogen, and water.

Air drift.—A drift connecting a ventilation shaft with the fan.

Air lock. — An intermediate passage closed at either end by a door, placed between airways, along which currents of different pressures are flowing. Persons desirous of passing from one airway to the other can do so without interfering with the system of ventilation or personal inconvenience.

Air receiver.—A strong vessel, into which air from a compressor is delivered, which serves as a reservoir to equalise the pressure before being consumed.

Air shaft. — A shaft used specially for ventilation purposes; generally the upcast.

Alligator.—A self-tipping tank, used for raising rock or coal while sinking stopes or jigs.

Anemometer.—An instrument used for determining the velocity of a current of air.

Arris-cleat.—A strip of wood, having a triangular cross-section used for keeping brattices in position.

Backing-deal.—Planks placed against the inside of shafts, the rock of which requires support; the planks are kept in place by wedging them against curbs. Generally used for temporary purposes prior to bricking up.

Band.—A thin layer of rock in a seam of coal.

Band-or strap-rope.—An endless rope that transmits power from the surface into the clutch-room underground, where the various district ropes are thrown into gear.

Bank.—The surface round about the top of a shaft.

Bank of ovens.—A row of ovens for converting coal into coke.

Banker off.—The man who attends to taking skips off the cage.

Banksman.—See Banker off.

Bar.—See Cap-piece.

Barrier pillar.—A long block of unworked coal left between two collieries, or between workings under water, and those under land, so as to guard against accidents.

Basin.—A coal basin is a large basin-shaped depression, in which coal seams occur.

Battery of ovens.—See Bank of ovens.

Beehive oven.—A coke oven, having the appearance of a large old-fashioned straw beehive.

Bell-sheave.—A sheave in the shape of a truncated cone, used in connection with the main and tail system of rope haulage at curves, so as to keep the rope close to the ground.

Billy.—A name used in the Clermont district of Queensland for a bed of quartzite that caps the coal measures.

Billy-fair-play.—A trough with a swinging bottom attached to a spring balance for weighing slack when it passes through the screens.

Black-damp.—Chiefly carbon dioxide gas, due to the oxidation of

coal; it is, however, never pure, and has a smell due to the presence of hydrocarbons.

Black-ends.—Inferior coke, generally found on the outside of a charge.

Black trucks.—A box-shaped truck, with end door, so-called because it is made black with tar.

Blower.—A sudden stream or outburst of fire-damp from a face of coal.

Blown-out shot.—A shot that has blown out the tamping of a hole without breaking the coal or rock as intended.

Bobbin.—A catch placed between the rails of the up-line of an incline to stop any run-a-way trucks. It consists of a bent iron bar, pivoted in such a manner so that the down-hill end is slightly heavier than the up-hill end, which is capable of being depressed by an up-coming truck, but rises above the level of the truck axle, as soon as the truck is past.

Bord.—A common bord is a long chamber driven at right angles to the facing. A narrow bord is four yards wide or less. A wide bord is over four yards in width.

Bord course.—A direction at right angles to the main cleat or facing, i.e., the length of a bord.

Bord and pillar.—A system of mining coal in which it is first won from bords or chambers, the roof being temporarily supported by pillars of coal left between them, but which are in most cases subsequently extracted.

Bottom gas.—A mixture of explosive gases collected in depressions in coal mines, probably made heavy by the presence of an excess of carbon dioxide over fire damp.

Bowk.—An iron bucket used for raising rock, etc., while sinking.

Brace.—A permanent platform on the head frame of a shaft on which men work.

Brakesman.—The man in charge of a brake which controls a gravity plane.

Branch rope.—See District rope.

Brasses.—A coal miner' term for iron pyrites in coal.

Brassy tops.—The top part of the Greta seam, in which there are large quantities of sulphide of iron.

Brattice.—A vertical division of boards or cloth to separate the intake from the return air currents.

Brattice trick.—A trick played on inspectors when measuring the air in a mine, the quantity of air being reduced in some districts below its normal amount, in order to increase it in the district being tested. Usually effected by placing a piece of brattice cloth across one of the return airways.

Breathing apparatus.—Apparatus connected with a mouth-piece or helmet, which enables the wearer to penetrate places full of foul gases.

Breeze.—Fine coke.

Bridge rails.—Rails made in the form of an inverted U, generally in short lengths, which are light to handle, and can be brought within easy shovelling distance of the face.

Bridle chain.—Short chains between the cage and the hoisting rope.

Broken.—Working in the broken is the process of removing the pillars in bord and pillar work.

Broken skip.—A skip from which some of the coal has fallen off in transit.

Brown coal.—A structureless variety of lignite.

Brush.—To brush the roof is to take down some of the rock overhead to make head room.

Buffer rope.—Ropes placed between the track of cages in a shaft

where rope guides are employed, so as to prevent the cages from colliding.

Bull.—See Dragbar.

Bunton. Horizontal timbers or steel girders placed across a shaft to support cage guides, pipes, etc.

Bye-pass. A short passage used to get past a place it is not advisable to cross, e.g., a shaft.

Cabin.—A small room, either on the surface or underground, e.g., a lamp cabin, deputy's cabin, or stump cabin.

Cage.—A movable platform, on which men and materials are raised or lowered in shafts.

Canch.—A thickness of stone necessary to be removed from top or bottom, in order to make head-room or to improve the gradient of the road.

Candle-power.—A sperm candle, that burns at the rate of 120 grains per hour.

Canister.—(1) A tin for holding blasting powder; (2) a hopper-shaped truck, from which coal is discharged into coke ovens.

Cannel coal.—So-called because it burns with a bright flame like a candle.

Canvas.—A miner's name for brattice cloth.

Carbonic dioxide.—A gas composed of one part of carbon to two parts of oxygen by weight. It is the chief constituent of choke-damp.

Carbon monoxide.—A poisonous gas caused by incomplete combustion, composed of one part of carbon and one part of oxygen. It is the poisonous constituent of white-damp.

Carburetted hydrogen.—A gas composed of one part of carbon to four parts of hydrogen. It is the chief constituent of fire-damp.

Cap.—(1) The pale bluish elongation of the flame of a lamp, due to the presence of fire-damp; (2) the socket attached to the end of a hoisting or hauling rope nearest to the cage or skip.

Cappice.—A horizontal stick of timber or bar of steel used for supporting a weak roof.

Cavil—Lots drawn at stated periods by hewers to determine the places in which they will work for the following term.

Chain-breast machine.—A coal cutting machine, so constructed that a series of cutting points attached to a circulating chain work their way for a certain distance under a seam; when the limit is reached, the machine is withdrawn and shifted to one side, where another cut is put in.

Chain pillars.—Pillars left to protect gangways and air courses, with which they run parallel; they are broken up into a chain of smaller pillars by stentons and bords.

Chairs.—The supports on which cages rest when at the surface.

Check-brakes.—An arrangement for automatically checking the speed of skip running down an incline unattached to a rope.

Check-weighman. A man appointed and paid by the miners to check the weighing by the company's representative of coal broken by various parties of men.

Cheese weights.—The circular cheese-shaped weights used to keep guide ropes taut.

Cherry coal.—A coal that burns freely without fusing.

Chidder.—Slate and pyrites mixed.

Choke damp—See Black damp.

Chocks.—Pieces of wood built up crossways in pairs, forming a hollow column, which may be filled in with rock. Used for supporting the roof.

Cindered coal.—A very inferior natural coke, little better than ash.

Clay band.—An argillacious iron ore, sometimes found in coal measures.

Cleat.—The smooth vertical partings which run through a seam, generally at right angles to one another, one set usually being more pronounced than the other.

Clip.—A means for fastening skips to the rope in the endless rope system of hauling.

Clipper-off.—A boy who unfastens the clip connecting a skip to a circulating rope.

Clipper-on.—A boy who fastens skips to a rope with clip.

Clutch room.—A chamber, generally underground, in which there are friction clutches that control the different ropes of the various districts being worked.

Coal.—A solid fuel, which occurs in seams, being the fossilised remains of organic matter.

Coal apple.—A spheroidal form of coal occasionally found in certain seams.

Coal box.—Large bins for storing coal.

Coal measures.—Seams of coal with their accompanying rocks of the same age.

Coal-puncher or pick-machine.—A coal cutter of the reciprocating type, used for undercutting and nicking coal.

Cod-piece.—A wooden fish-plate used for connecting the segments of a walling-curb.

Coffee-pot lamp.—An ordinary coal miner's naked oil lamp, similar in shape to a coffee-pot.

Coke.—The fixed carbon and ash of a coal sintered together.

Coking coal.—A bituminous coal capable of leaving a caked mass when heated in an oven so as to drive off the volatile hydrocarbons.

Coke-wharf.—A platform on to which coke is pushed when discharged from an oven.

Collar—A horizontal piece of timber or iron placed so as to support the roof of a gangway.

Collar of shaft.—The first wooden frame round the top of a shaft.

Collecting rope.—An endless rope used for bringing skips from where they are left by the main haulage system to the bottom of the shaft, thus saving much handling and the construction of a kip.

Colliery.—A coal mine, including the surface plant.

Consideration.—An extra payment given to men working under unfavourable conditions, e.g., in a wet place.

Copt.—A capsized or "broken skip."

Cross-head.—A runner or framework that runs on guides, placed a few feet above the sinking bucket in order to prevent it from swinging too violently.

Coupling chains.—See Bridle chains.

Coup-over.—A small chamber, into which an empty skip can be upset so as to allow a full skip to pass when there is only a single line.

Cradle.—The platform on which men stand while lining the inside of a shaft with bricks.

Creep.—The gradual rising of the floor or sagging of the roof in mine workings; sometimes erroneously confused with a "crush."

Creeper-chain.—A strong circulating chain, in which every few feet a horn is inserted, which catches the axle of a skip and draws it up an incline.

Cross-cut.—A passage driven diagonally to the facing of the coal.

Cross-gateway.—A road kept through the goaf, which branches off from the main gateway at an angle

Cross-heading.—A passage driven from one working place to another for ventilation purposes.

Crossing.—The place where two or more lines of rails going in different directions cross each other.

Crush.—The breaking-up of coal, and the rock overhead, when pillars or timber give way.

Cundy or conduct.—The passage under a roadway into which an endless rope passes out of the way at the end of its track.

Curb or crib.—A ring made up of segments or wood or iron used in connection with the lining of shafts. Walling or wedging curbs, wedged tightly in position, are used as a foundation on which to start brick lining or tubbing. A capping or holding-down curb is the top curb of a section of tubbing.

Curtain.—A piece of brattice cloth placed across a roadway, so as to dissect the air current.

Cut-through.—A connection between bords, used for ventilation and travelling purposes.

Dag.—A system whereby the earnings of members of the Coal-miners' Federation are practically equalised.

Dant.—A fine film of carbonaceous matter found on the joints of coal, sometimes called "Mother of coal."

Damp.—Gaseous mixtures in a colliery.

Dead rope.—See Buffer rope.

Declared selling price.—The nominal selling price of coal declared by the mine-owners in the Newcastle district, N.S.W., every September, on which the payment to miners is based.

Deficient place.—A working place in which men cannot make fair average wages, and for which they are given extra pay.

Deputy.—An underground official who is in charge of a certain area in a colliery.

Devil.—An automatic arrangement for detaching a set of skips from the main and tail rope system on their arrival at the kip.

Diamond —A pointed wooden or iron arrangement placed between rails, just before a curve, where skips are liable to be derailed, so as to enable them to mount the rails again. If the skips are travelling in one direction only, the diamond is pointed at one end, if travelling backwards and forwards on the same rails both ends are pointed.

Dip.—Working to the dip is when one works on a down grade.

Disintegrator.—A machine for breaking up coal into powder, prior to converting it into coke.

District.—A certain area of a coal mine into which it is found advisable to divide a colliery for convenience in working.

District rope.—A rope used for hauling skips in a district or section of a colliery.

Division rope.—See "Buffer rope."

Dog.—See "Dragbar."

Dog-clip.—See "Clip."

Dog-watch.—The night shift in a colliery.

Down-cast.—A shaft through which fresh air enters a mine.

Dragbar or back stay.—An iron bar fastened to the back of a skip to prevent the latter running backwards down hill in case the hauling rope breaks.

Draw.—To draw a pillar is to extract the pillar when working in the broken.

Driver.—A boy in charge of a horse and set of skips on a main roadway.

Dropping pillars and top coal.—The second working, consisting of drawing the pillars, and in thick seams fetching down the upper portion of the seam that was left temporarily in position.

Drop-sheet.—See "Curtain."

Drum sheave.—A cylindrical drum placed vertically on the inside of a curve, against which the main rope of a main and tail rope system moves when rounding the curve.

Dry coal.—Coals wanting in oily constituents.

D. truck.—A low side open truck, used for conveying coal for home consumption, and from which the coal has to be shovelled.

Duff.—The fine coal left after separating the nuts.

Dumb-drift.—A passage connecting the return airway with the upcast shaft, when ventilation is carried out with the help of a furnace. The connection is sufficiently high above the furnace so as to prevent the heat from igniting any fire-damp that may be present.

Dummy.—A couter-balance used on jigs which runs on a narrow-gauge between the jig rails.

Dyke.—A wall or sheet of igneous rock, cutting through other rocks.

Economiser.—A structure for making use of the waste heat from boilers.

Endless rope haulage.—A system of haulage whereby skips are clipped on to an endless circulating rope, the empties going in-bye and the full out-bye.

Engine plane.—An incline on which one set of skips are hauled up-hill by an engine, while the other set of skips run down-hill by gravity.

Exploder.—An electric machine used for firing charged holes.

Face.—The place where hewers work.

Facing.—The main vertical joints often seen in coal seams; they may be confined to the coal, or continue into the adjoining rocks.

False-bedding.—Laminations in rocks at an oblique angle to the proper bedding planes.

Fan.—A wheel provided with vanes which revolves, thereby inducing an air current.

Fan drift.—A short tunnel connecting the top of the air shaft with the fan.

Fast-heading.—See "Leading winning."

Fat-or gas-coal.—Coals containing much volatile oily matter.

Fault.—A fracture through rocks causing their dislocation. Miners not finding the same rock continuous on either side of the fracture are said to be at fault.

Fault coal.—A name used for inferior coal in the Clermont district, Queensland, which occurs not only near faults, but also away from them.

Fence.—An obstruction, such as a bar or cross-sticks, placed across an underground passage past which men have no right to travel.

Filler.—Men who fill the coal into skips.

Filling-out.—Shovelling into skips and taking to the surface. One speaks of filling-out burning material when a small fire occurs in a mine.

Fine coal.—See "Slack."

Finger-bars.—Iron rods attached to a cage with the ends bent in such a way as to keep the skips in the cage from running out while being raised or lowered.

Fire-damp.—A mixture of gases composed chiefly of light carburetted hydrogen and other hydrocarbons, with hydrogen, carbon dioxide, oxygen, and nitrogen.

Firemen.—Men who test workings for gas before miners go to their working places.

Flat.—An underground gathering station or siding.

Flat-sheet.—A flooring of boiler plate at crossings and at the top and bottom of a shaft, to facilitate the handling of skips.

Flatter.—The man who attends to the shunting at a flat.

Fleet angle.—The angle made between the two ends of a winding drum as a base, and the pit-head pulley as the apex.

Flitting.—Conveying a coal-cutting machine from one place to another.

Floor.—The rock below a coal seam.

Free-burning coal.—See "Cherry coal."

Fork-filled.—Coal filled into skips with a fork, having the tines about $1\frac{1}{4}$in. apart. This separates the bulk of the slack from the round coal, which should not have more than 10 per cent. of its weight of slack left in it.

Front and back shift.—A system sometimes used, in which one of a pair of mates comes to work two hours before the other, while the other remains two hours after the first has gone home; the object being to keep the wheelers going, who work 10 hours, against the miners' eight hours.

Gannon, ganning, or going bord.—Bords used for wheeling purposes. A travelling-way going in the direction of a bord.

Garland.—See "Water ring."

Gas coal.—Bituminous coal containing a large quantity of volatile hydrocarbons.

Gassing.—The effect of inhaling noxious gases on the animal system.

Gateway.—A road kept through the goaf in longwall working.

Geordie turn-out.—A turn-out from a heading to a bord made of iron bars of square cross-section instead of ordinary T rails, so that the same turn-outs can be used to the right or left by simply reversing them.

Gob, goaf, or goave.—That part of a mine from which the coal has been extracted, and the roof allowed to fall in, or the space stowed with refuse.

Gob-road.—A roadway built through the gob.

Gob-stink.—The smell of incompletely burning coal given off by an underground fire.

Gravity plane.—A tramline laid at such an angle that full skips running down hill will pull up the empties.

Greaser.—An apparatus over which skips pass, say, every mile, which greases the axles.

Green coal.—Freshly mined coal.

Grey-back.—A local name at Lambton B. for minor cleats that cross the main cleat.

Grey-heads.—Joints in the rolling country of the Southern Coalfield of N.S.W., which run parallel with the longer axis of a roll; these joints are generally coated with a whitish substance.

Grunching.—Shooting-fast, i.e., shooting in the solid. This makes more slack than when the seam is holed; but with the consolidated rate the slack is weighed as well as the round coal.

Guides.—Wooden rods, steel rails or ropes, arranged in a shaft, on which cages run, so as to keep them in their own particular path.

Hanging deal.—Planks used to suspend a lower curb from the one above it, in cases where backing deals are necessary.

Hard coal.—Another term for anthracite.

Heading.—A passage driven with the facing of the coal, or head on.

Head frame.—The structure above a shaft, on the top of which are fixed the pit head pulleys.

Heapstead.—The entire surface plant about a shaft.

Heave.—The displacement of a rock sideways by faulting.

Helper-up.—An assistant to a wheeler when the roads are bad.

Hewer.—The collier who mines the coal.

Hewing rate.—The rate of pay given miners for hewing coal.

Holding-down curb.—See Curb.

Holing.—(1) A horizontal cutting in or below a seam of coal made preparatory to breaking down the coal above it. (2) A connection made between two or more roads underground.

Hopper.—A bin for storing coal.

Hopper-truck.—Trucks made with a smaller area on the bottom

than on the top. The bottom is made to move on hinges, so that when run over a bin or lifted over the hold of a skip the contents can be completely emptied.

Hurdy-gurdy drill.—An auger used for drilling holes in coal by turning a handle.

Hydrogenous coal.—Coals containing a large quantity of moisture, e.g., brown coal.

Inbye.—Towards the working face from the surface.

Intake.—The passage through which fresh air is conducted to the workings.

Jenkin.—A place cut in a pillar of coal at right angles to the cleavage planes or in a bordways direction.

Jerry.—A carbonaceous shale found in the Borehole seam.

Jerry faces.—A local name at Lambton B. colliery for main cleats in coal.

Jig.—An underground gravity plane for conveying coal to a level below in a highly inclined seam.

Jigger.—A boy who attends to the brake of a jig.

Jockey.—A Y-shaped rope grip placed in sockets at the end of a skip. It is in this that the endless rope rests when used above the skip.

Jud.—That portion of a working face loosened by under-cutting and nicking.

Kerf.—The undercut made while mining coal.

Kick up.—An end tippler.

Kip.—A raised length of track on which skips are disconnected from a hauling rope, so arranged that the skips can gravitate as required to the bottom of the hoisting shaft.

Lampmen.—Men who clean, repair, and refill lamp for colliers.

Lamp station.—Places underground where safety lamps are allowed to be relighted, or may be exchanged when they become extinguished or damaged.

Leading winning.—A heading going in advance of the ordinary bords.

Leaners.—"Grey heads," whose faces incline towards the axis of a roll.

Legs.—The vertical supports of a cap-piece.

Level.—A nearly horizontal passage running in the direction of the strike of a seam.

Lid.—A board placed on the top of a post, so as to give it a better bearing against the roof.

Lift.—A slice taken off a pillar when winning it.

Lignite.—Brown coal, with a woody structure.

Little tops.—The name given to a thin band of coal occurring above the "Jerry," in the Borehole seam.

Living wage.—The amount of money that is considered necessary to allow a man with a wife and family to live without privation.

Lodgment.—A place specially cut out or old workings to the dip, where water is allowed to accumulate.

Longwall.—A system of winning coal in long faces without leaving any pillars, except about shafts and the main roadways.

Loose rails.—Rails that can be lifted and placed across a permanent line when desired to run skips across it.

Lorry.—See "Running bridge."

Lump coal.—All coal passing over the main screen.

Machinist.—The man in charge of a coal-cutter.

Main and tail rope haulage.—A system of haulage whereby a set of skips connect two ropes, one known as the main, the other as the tail-rope. The main rope hauls the full skip out, while the tail rope draws the empties into the mine.

Marsh gas.—Light carburetted hydrogen.

Mineral conditional purchase.—An obsolete N.S.W. Act, whereby anyone improving his land to the extent of £2 per acre becomes possessed of the right to all minerals on the property, with the exception of gold.

Missfire.—A charge that does not explode when fired.

Monkey-chock.—See "Bobbin."

Morgan.—A band of carbonaceous shale occurring in the Borehole seam.

Mother of coal.—See "Dant."

Mouth of pit.—The top of a shaft.

Naked light.—Any light that is not covered or protected in such a way as to prevent the ignition of fire-damp.

Narrow place.—Working places that are less than six yards wide; these are paid for by the yard in length.

Natural coke.—Coal that has been more or less coked by contact with an igneous rock.

Needle timber.—Long sticks of timber, the lower end of which rests against the foot of a prop in a steep seam, so as to keep it in position, while the upper end is let into a hitch in the roof.

Nicking.—A vertical cutting or shearing up the sides of a face of coal so as to free the ends of the block that has been undercut.

Nominal selling price.—See Declared selling price.

Nuts.—Coal less than ¾in. and over 3-16in.

Onsetter.—A man who has complete control of the pit bottom; he cages and uncages the skips and signals to the engine-driver.

Outbye.—In a direction towards the entrance to a mine.

Overcast.—A passage through which one air current is conveyed over another airway.

Overweight.—The settling down of the upper rocks when working by the longwall system. It is regulated by the packwalls. If it settles too quickly, it binds the underweight, causing the latter to throw too much weight on the face.

Packwall.—A wall built up of rough stones. They are used, for instance, on either side of a mine roadway through goaf to support the roof, and keep the sides in place.

Panel.—A division or district of a colliery separated from other districts by barrier pillars.

Parting.—A thin stratified layer of foreign material in a seam.

Pass-bye.—(1) A passage round the working part of a shaft. (2) That part of a single track where the lines are doubled, so that ingoing and out-going skips can pass one another.

Patent fuel.—Fine coal cemented together with pitch or tar, and compressed into bricks.

Penthouse or pentice. — A protection built above men when shaft sinking.

Permitted explosives.—Certain explosives allowed to be used in fiery mines, which are mentioned periodically in "Statutory Rules and Orders," issued by the Home Office, London, which are supposed to be safe.

Pick-or punch-machine.—A reciprocating machine, used for undercutting coal by repeated blows.

Picking belt.—A revolving belt made of sheet iron placed horizontally or at an angle, used for conveying coal to a bin or waggon, while boys pick out any shale or brasses.

Pillars.—A solid block of coal left as a support or barrier, while working a colliery, e.g., shaft pillar, chain pillar, barrier pillar, bord and pillar, etc.

Pillaring.—The process of extracting pillars.

Pit.—(1) A shaft. (2) A coal mine.

Pit-top.—The structures about the mouth of a shaft.

Pit water.—The moisture found in freshly mined coal, which is lost by exposure to ordinary atmospheric conditions.

Place.—The portion of a coal face allotted to a hewer.

Post.—(1) Clayey sandstone. (2) See "Prop."

Primer.—The small plug placed on the top of a charge of high explosive in which the detonator is embedded.

Prop.—A vertical stick of timber used as a temporary support for the roof.

Rake of skips.—A number of skips connected together that form a set or train.

Rams.—(1) The plunger of a pump. (2) A mechanical device for pushing hot coke out of an oven.

Regulator.—A door in a colliery by means of which the ventilation of a district may be regulated.

Relighting station.—Places underground where safety lamps that have become extinguished may be relighted.

Return tunnel.—A tunnel used as a return airway.

Rib.—A narrow pillar of coal left as a support.

Rider.—See Cross-head.

Rise.—Working to the rise is when one works on an up-grade.

Roadman.—Men who lay tracks, see that they are kept in order, and who attend to various odd jobs below.

Roadway.—An underground passage, whether used for haulage purposes or for men to travel to and from their work.

Rolls.—When earth stresses cause the floor of a seam to form wave-like folds, which thins out the coal at their crests.

Roof.—The rock immediately above a coal seam.

Rope drive.—When ropes take the place of belts for driving machinery.

Round coal.—Coal which passes over screens, with bars ¾in. apart.

Rubbing bars.—Bars placed on the side of a cage nearest to the other cage when rope guides are used. The buffer ropes are placed outside the rubbing bars.

Run-away switch.—A switch by means of which a run-away truck can be side-tracked.

Run-of-mine.—Coal as broken in the mine.

Runner.—See Cross-head.

Running bridge.—A platform on wheels which serves as a cover for a shaft in process of sinking, and on which buckets or skips are landed.

Safety catch.—An appliance attached to a cage so that should the hoisting rope break, the catches grip guides, thus preventing the cage from falling.

Safety detaching hook.—A self-acting device, which releases the cage from its hoisting rope in case of an overwind.

Safety fuse.—A core of fine gunpowder encased in a tube of tape and tar, used for exploding holes.

Safety lamp.—A miner's lamp, protected in such a manner that the heat of the flame is not communicated to the explosive mixture of gases outside.

Screen.—An apparatus for sizing coal.

Screened coal.—Coal that has passed over a screen and had the slack separated from it.

Screen Men.—Men who attend to the tippler and screening of coal.

Scotches.—A sprag or brake for skip.

Sealing a mine.—The air-tight closing of the entrances to a coal mine, resorted to in time of fire.

Seam.—A bed of coal.

Second or back explosion.—Supposed to be due to the ignition of

gases developed from highly heated coal dust, and gases sucked out of the faces of coal by the partial vacuum resulting from the primary explosion, or liberated by falls of roof.

Second working.—The extraction of pillars left by the first working.

Self-acting incline.—See Gravity plane.

Set.—(1) A set of skips, is a rake or row of skips connected together to form a train. (2) The timbers which compose any framing, whether for a roadway or a shaft. (3) To place a prop in position.

Set rider.—The man who accompanies a set of skips hauled by the main and tail rope system, so that he can attend to any points on the track, unfasten the rope, and signal to the engine-driver as required.

Shaft.—A vertical or highly inclined pit sunk in connection with mining operations.

Shaft pillars.—The solid block of ore left about a shaft in order to protect it from being destroyed.

Shandy-gaff.—Shovel-filled coal.

Shearing.—See Nicking.

Shift.—The number of hours constituting a man's ordinary daily work.

Shiftmen.—Men engaged on wages at various jobs.

Shipper.—An instrument used for placing an endless rope on its rollers in cases where it gets off them.

Shoes.—(1) The bottom wedge-shaped piece attached to tubbing when sinking through quicksand. (2) Steel pieces fastened to the ends or sides of cages, which slide on guides when the cage is in motion.

Shooter or shot firer.—The man who fires a charged hole after satisfying himself that the place is free from fire-damp.

Shooting fast.—Shooting in the solid, i.e., making powder do all the work without holing or undercutting.

Shortwall machine.—A coal cutter for use in bords, which, when once the cutting part has made the sumping cut, is drawn across the face automatically by ropes, undercutting as it proceeds.

Shot.—The explosion of a charged hole.

Shovel filled.—Run-of-mine coal as broken at the face.

Skip.—A coal miner's truck.

Skirting.—A road driven next a fall of stone or next to an old fallen place.

Slack.—Fine coal, which will pass between bars ⅝in. apart.

Slack box.—A bin in which slack is stored.

Slant.—An inclined roadway.

Slip.—A small fault.

Slip hook.—A hook, generally on a hinge, which can be readily disconnected by withdrawing a cotter bolt that holds it in position.

Slope.—An inclined roadway, generally driven from the surface.

Small coal.—See Slack.

Speak.—Props are said to "speak" when they give signs of weight by cracking.

Spear-wedges.—Long wooden wedges, used for centering iron tubbing, and which help to pack up the space between the tubbing and the rock.

Special places.—Development and difficult places, where coal cannot be won so easily as in ordinary working places.

Splint or splent coal.—An inferior laminated dull-looking coal containing much ash.

Split.—(1) To divide an air current into two or more; also the divided current itself. (2) When a coal seam is divided by a parting into branches, it is said to split.

Spontaneous combustion.—Combustion started by natural means.

Sprag.—(1) A piece of wood or iron placed between the spokes of skip wheels, which jambs against the bottom of the skip and pre-

vents it from travelling. (2) A short wooden prop, placed in a slanting position to support the upper part of a seam during or after "kirving" or undercutting.

Squeezer.—An apparatus used to check the progress of skips running loose on rails, by means of a weighted angle iron that presses on the tread of the skip wheels.

Squib.—A tube of paper, a straw, or quill filled with fine-grained gunpowder, at one end of which a slow match is fixed; used for firing shots.

Stall.—A narrow chamber or breast.

Stall road.—A roadway along which coal worked in a stall is conveyed to the main roadway.

Standard height.—A given height of seam, say, 5ft., below which the miner is paid so much extra for every inch.

Standard selling price.—An assumed price, not necessarily the actual selling price, adopted so as to afford a basis for a uniform hewing rate.

Steam coal.—A hard, free-burning, non-caking coal.

Stem.—To tamp a hole prior to blasting.

Stemming.—Material used in the operation of tamping a charged hole; also the process of tamping itself.

Stenton.—A connection made between parallel roadways for ventilation purposes.

Stint.—The amount of work to be done by a man in a given time.

Stone coal.—Anthracite.

Stone drift.—A passage driven in rock instead of coal.

Stone man.—A man who works in rock, in contradistinction to one who works in coal.

Stook.—A block of coal a few yards square left to support the roof in certain stages of pillar working.

Stop.—A device for blocking skips from proceeding when standing on rails.

Stopping.—An air-tight wall, built across a mine passage, in order to direct the air current.

Stower.—Men who stow away waste in old workings.

Straight point.—That straight portion of the inner main rail between the rails of a turn-out.

Stringer.—A beam of timber placed longitudinally.

Stripping a jig.—The forming of a jig by enlarging a cut-through on an incline.

Stump.—The pillar left between the roadway and each bord turned off from it.

Sulphur.—Iron pyrites.

Sumping-hole.—The first or opening cut made by a coal-cutter.

Sweep-point.—The curved rail of a turn-out that crosses the main rails, and is moved against or from the outer main rail, according to the track it is desired the skip shall run on.

Sweep rail.—The inner curve of a turn-out.

Switch.—(1) The movable tongue whereby skips are diverted from one track to another. (2) An arm used for changing the course of an electric current.

Tail sheave.—The return sheave for an endless rope or the tail rope of the main and tail rope system, placed at the far end of a haulage.

Tamping.—See Stemming.

Tell-tale board.—A board studded with hooks on which colliers place a token on which their special number is stamped, before entering the workings, so that the officials can know who is below.

Tender roof.—A roof that requires to be well supported.

Tension pulley. — A pulley round which an endless rope passes.

mounted on a trolley or other movable bearing, so that the slack of the rope can be readily taken up by the pull of weights.

Thimble.—The iron ring placed a few feet below the pit-head pulley which supports the safety detaching hook in case of an overwind.

Third-hand assistant.—A boy, who helps the machinist and his assistant with a coal-cutting machine.

Throw.—The vertical displacement of a fault.

Throw-off switch.—A switch by means of which an obstruction is thrown across the rails of a track, causing the derailment of trucks.

Thrust.—The cutting up of the roof by the pressure of remaining pillars of coal in a partly-worked coal mine.

Tipper.—The man who runs skips into a tippler.

Tipple.—The tracks, trestles. screens, etc., at the entrance to a colliery where coal is screened and loaded.

Tippler.—An apparatus for tipping a skip up, so as to empty it of its contents.

Token.—A metal or leather ticket stamped with a distinctive number fastened to a skip so as to indicate to the weighman what party mined the coal.

Tommy dodd.—A series of small pulleys, with vertical axles placed between the rails at a curve, so as to keep an endless rope in place.

Tonnage rate.—When miners are paid by the ton.

Top coal.—The upper portion of a thick seam, often left to be extracted at the same time that the pillars are drawn.

Top-gas.—Fire-damp.

Top man.—Any man employed about the surface.

Trailer cable.—A branch cable for conveying electricity to a coal-cutter, one end of which is clipped to the main cable. It is capable of being paid out as the machine advances.

Trapper.—A lad whose business it is to open and close ventilation doors in roadways along which hauling is done.

Travelling belt.—A conveyor belt.

Travelling road.—An underground gangway, along which men travel to and from their work.

Travelling weight.—See Underweight.

Trepan.—A composite tool for boring holes of large diameter in rock.

Triple entry.—A system of opening a mine by driving three main parallel entries.

Tub.—See Skip.

Tubbing.—The lining of a circular shaft, generally of cast iron, but sometimes of brick or timber, used to keep back water.

Turn off.—The point where a branch line junctions with another line.

Turn out.—A siding or passing place for skips on a haulage road.

Twin seam.—Two seams of coal so close together that they can be worked in conjunction or one following closely on the other.

Undercast.—An air passage carried under another air course which is the more important roadway.

Underweight.—The travelling weight which rolls forward on the face of the coal in longwall work, and breaks down the strip that has been undercut.

Unscreened coal.—Run-of-mine coal.

Up-cast.—A shaft up which air ascends.

Up-set.—See Copt or Broken skip.

Vend.—A combination of colliery owners in the Newcastle district, having for their object the regulation of the coal trade.

Viewer.—An old term for a general manager or mining engineer of one or more collieries.

Walker shutter.—A shutter having a V-shaped cut in it, provided

for large ventilation fans of the Guibal type, which by cutting off the discharge of air gradually, reduces the vibration.

Walling curb.—A curb on which a wall is built for a shaft lining.

Washing coal.—Dressing coal in order to get rid of dirt associated with it, so as to reduce the ash forming material.

Wash out.—The erosion of part of a seam by aqueous action.

Water baler.—A man who bales water out of dip workings in places where it is not convenient to put in a pump.

Water gauge.—An U-shaped glass tube, containing water, by means of which the pressure of an air current can be measured.

Water-ring.—A trough let into the wall of a shaft in which water collects, and is led down pipes to a pumping station.

Water table.—A horizontal surface drain placed across a track.

Wedging curb.—A ring of wood or cast iron securely wedged in position at the bottom of a section of tubbing, so as to form a watertight joint.

Weighman.—A man who weighs the coal as it comes out of the mine.

Well hole.—The sump, or portion of a shaft below the place where skips are caged at the bottom of the pit; used for water to collect in.

Welsh-bord.—A bord in which the waste is stored in the middle, and a roadway is kept open on either side.

Wet place.—A place is considered wet if men have to work constantly in 3in. of water or more, or when water is constantly dripping on them from the roof.

Wheeler.—Lads who drive horses that draw skips to and from working places, and the nearest collecting station.

White-damp.—Carbon mon-oxide, a very poisonous gas.

White stone.—An indurated clay band in the Greta seam, thickly strewn with plant impressions.

Whole-working.—Working in the whole, or first working of a seam, by which it is divided up into pillars.

Wind blast.—A quantity of air driven out with considerable force by a fall of roof.

Winning bord.—A bord from which coal is being won.

Winning-off.—A leading heading or drive in advance to win room for bords. Any leading drift is termed a "Winning."

Winning pillars.—Extracting coal pillars.

Working bord.—See Winning bord.

Working, first.—See Whole-working.

Working in the broken.—See Second working.

Yardage.—A price paid per yard for cutting coal, in addition to the tonnage rate, in order to compensate for the breaking of coal more frequently from the sides in narrow places. The amount of yardage paid varies with the width of the working place.

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